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Skin Effect in Viscose Rayon

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The differential staining of the "skin" and "core" of viscose rayon by certain dyes has been previously explained on the basis of a more highly oriented skin. Improved methods of staining, developed in the present investigation, show that the formation of a skin is more closely related to the crystallization rate of the cellulose in the spinning bath than to the orientation resulting from stretching. A possible mechanism for skin formation is suggested and the relationship of fiber structure to fiber properties is discussed briefly.

THE growing importance of strong, tough rayons suitable for tire cords has added interest to the observation [4] that all rayons of this type have a comparatively thick skin, in contrast to the older types of textile rayon, which have a thin skin.

The "skin effect" in viscose rayon has been the subject of considerable inquiry since it was first demonstrated by Preston [6], Ohara [5], Schramek [8], and others. Earlier, the existence of an outer layer or "skin" of cellulose with different physical characteristics had been postulated by Hall [1], but since its experimental demonstration [6, 5, 8] very little progress has been made regarding its fine structure or the nature of the spinning variables affecting its formation. Previous investigators have limited their studies to the staining behavior of different dyes and to the theory of dye absorption, assuming that the differential staining behavior of the skin is due primarily to its higher degree of orientation.

The present investigation is concerned with (1) the further development of staining techniques for differentiating skin and core, (2) a study of the various factors which influence skin formation during spinning, (3) the mechanism of skin formation, and (4) a study of the fine structure of skin and core, and its relationship to physical properties.

Previous Work

Formation of Skin

The formation of a "skin" and "core" was explained by Preston [6] as follows: Viscose consists of unoriented cellulose micelles. As these pass through the spinneret orifice, surface friction tends

to orient the micelles at the outside of the stream but has little or no influence on those at the center. Thus, when the viscose comes in contact with the acid bath, there is formed a surface skin of solid cellulose containing well-oriented micelles. Acid then diffuses more slowly through this skin to form an unoriented core. The difference in dye absorption behavior of skin and core, according to Preston, depends upon this difference in orientation. Preston further observed that when a rayon possesses a skin it also possesses a serrated cross section. This, he explains, is due to the initial formation of a skin, followed by a rapid diminution in cross-sectional area due to osmosis, which makes it necessary for the large peripheral skin to adapt itself to a small area.

Independent of the orienting effect of the flowing viscose, Preston recognized stretch as a second orienting influence which occurs after the viscose is coagulated. If stretch takes place due to friction in passing through the bath, then much of the stretch will occur while the core is still liquid. This will increase the skin effect since the skin will be further oriented without orienting the core. On the other hand, if the thread is stretched by godet wheels or friction guides after the core is coagulated, this will orient the skin and core equally and decrease the skin effect. Thus, according to Preston, depending upon the value of the stretch, and on the stage at which it is applied, the filaments will vary in properties from those having an oriented skin and an unoriented core, on the one hand, to those approaching equal axial orientation throughout the cross section, on the other hand.

Schramek and Zehmish [7] also assumed the difference in skin and core structure to be largely that of orientation, but explained the greater orientation of the skin on the basis of a greater acceleration of motion at the skin. In passing through the jet, the viscose at the center acquires a higher velocity than that at the outside. Since the viscose at the outside is the first to be set-up, and since the whole filament is pulled away at a uniform speed, the acceleration or stretching therefore must be greatest at the fiber periphery, and this produces a more pronounced orientation in the skin.

Staining Behavior of Skin and Core

Preston [6] showed that Congo red selectively stained the center of a "milky" viscose filament, leaving a distinct outer layer of undyed cellulose. Congo red, although classed as an acid dye, is much like the substantive dyes, which have been rather extensively investigated by Schramek [8], with respect to its behavior in showing the fine structure of viscose yarn. Schramek found that the core is quickly stained by a dye with a rapid rate of diffusion, whereas a dye with a slow rate stains first the core and then gradually the whole fiber. However, if a cross section dyed at the slow rate is "cleared" by washing with water, then the dye is removed from the core, leaving the skin colored. The difference in rate of diffusion of the above types of dyes makes possible the staining of either the skin or the core, but the technique has certain definite limitations. For example, there is often a reversal of color effects, and dyes that normally stain the skin may stain the cross section of a filament from old viscose as if it were all skin.

Another type of skin-core differentiation is reported by Ohara [5], who used Oxamine Blue 4R. This dyed the core blue and the skin rose-to-red. Ohara's explanation is that the fiber acts as a membrane which separates the colloidal dye particles into different sizes, the smaller, red particles penetrating the skin, and the larger, blue particles, the core. Schramek [8], however, believes that the differential staining of Oxamine Blue is due to a chemical rather than to a colloidal heterogeneity of the dye. Schramek further pointed out that Diamine Blue 3B and Benzo Pure Blue are similar to Oxamine Blue in that they stain the skin red and the core blue.

Experimental

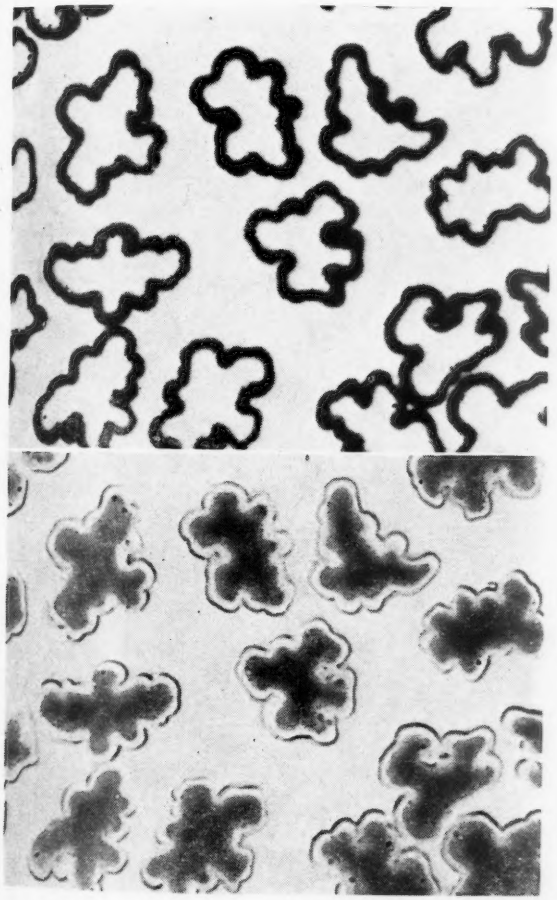
Development of Staining Techniques: Procedure

By using 10 percent water, 90 percent dioxan as a solvent, it was found early in the present investigation that, provided the dye was soluble in this solution, the core only was stained. This increased the sharpness of the differentiation since the skin now remained unstained. This procedure, when applied to cut cross sections, gave excellent results with a thick-skin yarn but, owing to diffraction effects at the fiber surface, was less satisfactory as the skin became thin.

During the search for a satisfactory dye that could be used for the skin, a peculiar behavior was observed with Victoria Blue "B," a basic dye. Although soluble in 10 percent water, 90 percent dioxan, this

dye did not stain dry cross sections, whereas a water solution of the same dye stained the entire filament. However, when 90 percent dioxan, 10 percent water was used as a "clearer" for yarn stained in a water solution of Victoria Blue "B," the color was removed from the core, but not from the skin. The tenacity of Victoria Blue for the skin is so strong that yarn has remained in the dioxan-water clearer for several weeks without its removing the color from the skin.

This technique made possible a sharp differentiation between the skin and the core, and later, when it was found that the clearing of the core and its staining with a contrasting color could be accomplished with one operation, the procedure was shortened appreciably. A number of dyes can be used to stain the core, but for black-and-white photomicrographs it is preferable to use a yellow or red dye, since either the skin or the core may be emphasized by the use of suitable light filters.



FIGS. 1A AND 1B. *Effect of photographic filters: Typical tire cord yarn stained with Victoria Blue and Calcomine Yellow. A (top)—Photographed with Wratten B and E filters to show skin as black (900 ×). B (bottom)—Same field photographed with Wratten C and H filters to show core as black (900 ×).*

Solutions. Victoria Blue: Make up a 2% aqueous solution of Victoria Blue B.S. Conc. (General Dyestuff Corp.). Add dye to boiling distilled water, cool, and filter. (May be used 4–6 weeks.)

Calcomine Brilliant Yellow: Dissolve 0.1 g. of Calcomine Brilliant Yellow Conc. (Calco Chemical Co., Bround Brook, N. J.) in 5 cc. of hot water and add 45 cc. dioxan (Eastman 1–4 Dioxan (Histological) No. 2144X). This is the correct quantity for the standard Coplin staining jar. If the stain is kept in the Coplin staining jar, keep volume constant by addition of 100% dioxan. Stain may be used 4 weeks.

Wash Solutions: Four wash solutions are prepared: No. 1—100% dioxan; No. 2—90% dioxan, 10% water; No. 3—90% dioxan, 10% water; No. 4—100% dioxan.

Procedure. Sections are cut 2–10 μ thick by the paraffin method, mounted on slides with Meyers albumin fixative, dewaxed by two changes of Xylene, placed in 95% ethyl alcohol for 2 min., 60% ethyl alcohol (by volume) for 2 min., 30% ethyl alcohol for 2 min., and stained in Victoria Blue solution for 1–2 hrs. After staining, the slide is rinsed in distilled water, allowed to drain, and the water is wiped from the back of the slide (to prevent excessive dilution of wash solutions). The wash solutions are then used as numbered: Nos. 1, 2, 3, for 5 secs. each, and No. 4 for 5 to 20 secs. The slide is allowed to dry and is then stained for 1 hr. in the Calcomine Brilliant Yellow. This completes the staining, and the sections are now rinsed in wash solution No. 3 for 5 secs. and in No. 4 for 10 secs. to 1 min. and, after drying, are ready for mounting with Fisher "Permount."

In the above procedure the dioxan-water concentrations are critical.

The use of contrasting stains (Victoria Blue for the skin and Calcomine Yellow for the core) has the advantage of emphasizing either the skin or the core with the appropriate light filters. The Victoria Blue-stained skin has the greatest contrast with Wratten B and E filters, whereas, conversely, the yellow core may be shown best with C and H filters. This is illustrated in Figures 1A and 1B.

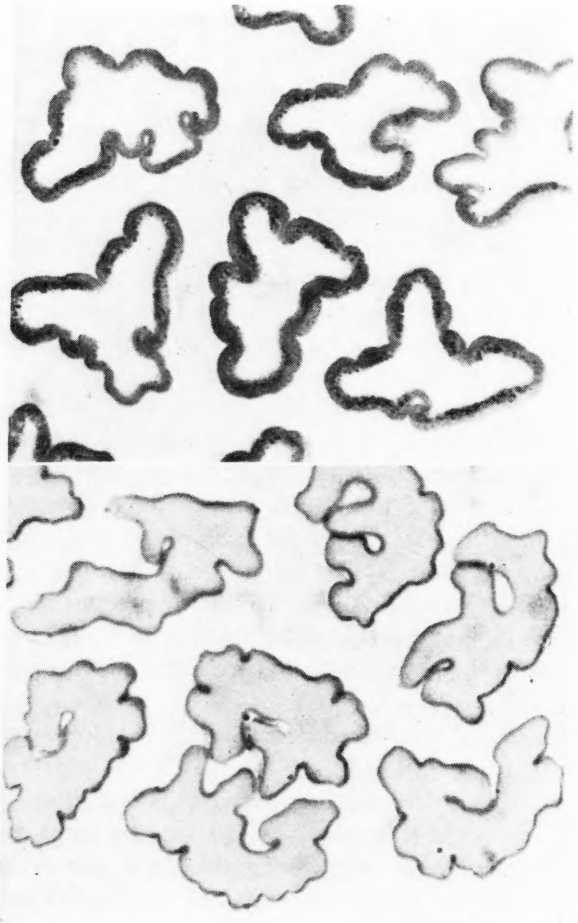
Effect of Spinning Variables

By controlling the composition of the viscose and the spinning bath it is possible to produce a filament which varies from a thick-skin one to one which has no skin at all. In general, the skin thickness is increased by varying the viscose, as follows: (1) increasing the D.P. of the cellulose, as illustrated in Figures 2A and 2B; (2) increasing the cellulose concentration; (3) increasing the amount of CS_2 used during xanthation; (4) decreasing the age (raising the salt test) of the viscose, as illustrated in Figures 3A and 3B; and (5) either increasing or decreasing the NaOH concentration, depending upon the starting concentration.

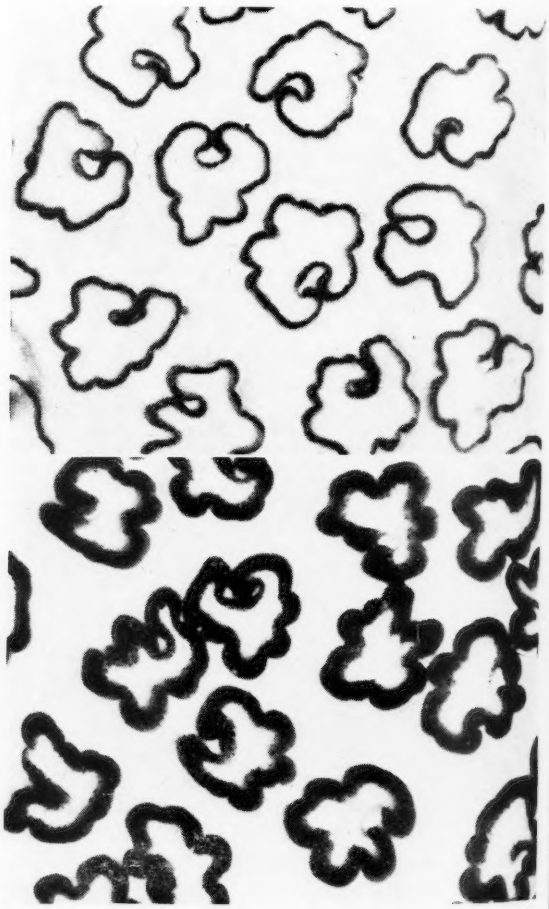
By varying the spinning bath the skin thickness can be increased by (1) decreasing the acid concentration, (2) increasing the salt (Na_2SO_4) concentration, (3) increasing the concentration of certain metals, such as Zn, Fe, Mg, Ni, etc., as illustrated in Figures 4A and 4B, and (4) by lowering the temperature.

In the above statements concerning viscose and bath variations it is assumed that when one factor is varied, all other variables are at their optimum conditions; otherwise the effect may be neutralized or even reversed, since the various factors are all interrelated and their effects are not additive.

As a general rule, spinning conditions such as spinneret hole size, filament size, bath immersion distance, spinning rate, godet stretch, etc., have little effect upon the skin thickness. The present experiments indicate that the skin and core structure is formed in the bath within a short distance of the jet face and that subsequent operations may modify but



FIGS. 2A AND 2B. *Effect of degree of polymerization: Cross section of fibers spun under similar conditions, except in A (top) cellulose D.P. = 827 (900 ×). B (bottom)—Cellulose D.P. = 191 (900 ×).*

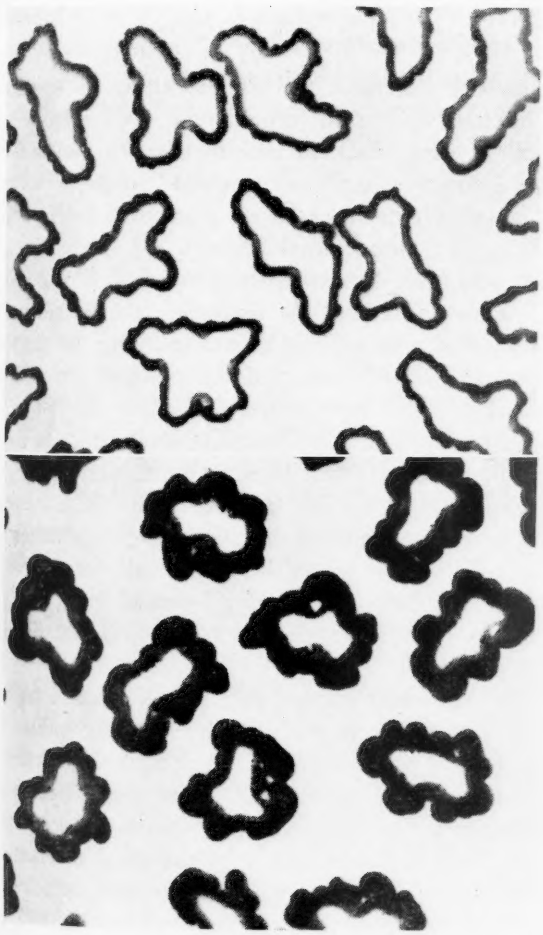


FIGS. 3A AND 3B. *Effect of viscose age: Fibers spun under same conditions, except in A (top) salt test = 2.3 (900 ×). B (bottom)—Salt test = 6.4 (900 ×).*

do not create or destroy the skin. For example, increasing the godet stretch apparently causes the skin and core to approach each other in orientation, but it does not greatly modify the differential staining between skin and core.

Effect of Subsequent Factors

After the filament is once formed, subsequent processing treatments such as washing, desulfurizing, bleaching, drying, etc., have little or no effect on the skin. However, when any treatments begin to cause a pronounced change in fiber properties, then the difference in staining between skin and core decreases. This occurs, for example, if the fiber is severely degraded by hydrolysis or oxidation or is treated with a mordant or a resin-forming material such as formaldehyde. This behavior is to be expected since the difference in skin and core is at a maximum in the untreated fiber, and anything that modifies the cellulose decreases this difference and causes the skin and core to stain in a similar manner.



FIGS. 4A AND 4B. *Effect of zinc in spinning bath: Fibers spun under same conditions, except in A (top) $ZnSO_4 = 1$ percent (900 ×). B (bottom)—$ZnSO_4 = 9$ percent (900 ×).*

Comparison with Other Fibers

Native cellulose fibers, such as cotton, ramie, and wood-pulp fibers, all have staining reactions similar to those of the core of a viscose rayon filament, as illustrated in Figure 5.

Likewise, fibers such as Fortisan, which have been formed by the hydrolysis of a cellulose derivative, possess no skin. Cuprammonium rayons and fibers first spun into a coagulating bath such as ammonium sulfate, and then put into a regenerating acid bath, also have no skin. The same is true of fibers spun into a strong acid bath, as in the so-called Lilienfeld process, illustrated in Figure 6.

Structure of Skin and Core

The exact structural difference between skin and core is difficult to demonstrate experimentally. X-ray and microscopic tests throw some light upon this question, but x-ray diffraction studies are limited, since so far it has been impossible to isolate a section of the skin for analysis. However, from a comparative study of the line breadth of x-ray diffraction lines of thick- and thin-skin yarns, there is evidence that the degree of crystallinity or lateral order is less in the thick-skin yarns. From the intensity distribu-

FIG. 5. *Cotton fibers: Cross section stained with Victoria Blue and Calcomine Yellow. Photographed with Wratten C and H filters (900 ×).*

tion curves taken around the diffraction ring, one finds that a portion of the cellulose is more highly oriented in the thick-skin yarns. Orientation, as measured by the refractive index method, is also higher for the thick-skin yarns. These results all point to the conclusion that the skin has a higher degree of uniaxial orientation but a lower degree of lateral order. In other words, the skin contains smaller and more fiber-like crystallites than the core.

Cross-section swelling measurements of skin and core show that in water the core swells about 40 percent more than the skin. Since less swelling is usually associated with a slower penetration and less dye absorption but greater dye-fastness, the swelling results are in agreement with the staining results. Liesegang [2] also found that the core dyes more readily than the skin but that the skin retains the dye longer in washing at high temperature.

Discussion

It should be pointed out that the terms "skin" and "core" do not connote two widely different types of material. Both are produced from the same stream of viscose, and there is no evidence to indicate that the skin and core are different in any way except in some peculiarity in physical structure which is most easily demonstrated by a difference in dye absorption. Furthermore, this difference in dye absorption shows only the presence of a skin and how thick it is, and does not differentiate between various "types" or "varieties" of skin. Accordingly, with these limitations in view, the skin will be defined in the present discussion as that outer layer or portion of the filament which retains its blue color after it is dyed in an aqueous solution of Victoria Blue "B" and cleared in a 90 percent dioxan, 10 percent water solution.

In considering the skin effects obtained by this method, it should be remembered that they are different from those obtained when the yarn is dyed in skein or fabric form. In all of the stained cross sections shown in Figures 1–6, the staining was carried out on the cut cross sections so that the whole cross section is equally available to the staining and clearing treatments. In skein dyeing the dye must first penetrate the skin before reaching the core. For this reason skein or fabric dyeing may also show "ring effects" in addition to "skin effects." When true skin effects are shown with skein dyeing, the skin is usually dyed lighter than the core.

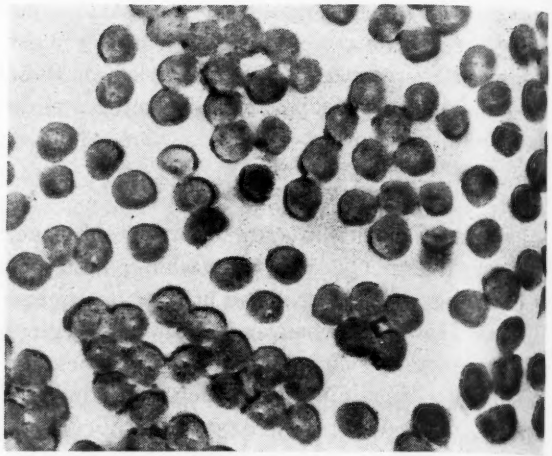


FIG. 6. *Lilienfeld yarn: Cross section photographed with Wratten C and H filters to show core black; no skin present (900 ×).*

Effect of Structure on Staining

As one considers further the effect of spinning conditions upon skin formation, it becomes obvious that the skin effect, as indicated by a difference in dye absorption, does not originate solely by means of either of the mechanisms postulated by Preston [6] or by Schramek and Zehmish [7]. The concept of a skin being formed entirely as a result of greater orientation forces at the surface is not in harmony with the observation that rate of spinning, jet stretch, and godet stretch have little effect upon the formation of a skin. Furthermore, it is not necessary to draw the filament away from the jet in order to form a skin; a skin is still present if the viscose is extruded freely into the spinning bath. The critical factor which appears to determine largely whether or not a skin is formed is the type of viscose and bath used rather than the orienting forces of draft, surface friction, or acceleration which may operate during spinning.

As previously pointed out, the skin has a higher degree of axial orientation, which greatly influences its physical properties, but this increased orientation is not the major factor which causes the difference in dye absorption. In fact, it is possible to keep the same skin thickness and vary the axial orientation over a wide range by changing the godet stretch and keeping the viscose and the bath constant, or to keep the same orientation and vary the skin thickness by changing the viscose and the bath and adjusting the godet stretch.

That the selective staining of the skin in viscose

rayon is not due entirely to a higher degree of orientation is further supported by the fact that x-ray diffraction and microscopic studies show that some fibers which have no skin, such as Lilienfeld and Fortisan, possess a much higher degree of orientation than does the skin of a viscose rayon. In addition to axial orientation, these fibers possess a higher degree of lateral order or crystallinity. The staining differential between skin and core, therefore, appears to be primarily a matter of crystallization rather than of orientation.

Mechanism of Skin Formation

In considering the explanation of skin formation, it must be recognized that the picture is oversimplified and that the explanation is based upon a large number of observations and published statements, a detailed description of which is beyond the scope of the present paper. Furthermore, the explanation is advanced at this time merely as a tentative working hypothesis based upon the information now available, and hence it is subject to modification as new data are accumulated regarding this most complicated problem.

The most logical explanation for a differential staining of skin and core appears to be a difference in the filament setting-up mechanism which influences the degree of crystallization or lateral order. Since the presence of xanthate groups on the cellulose and the presence of a di- or trivalent metal, such as Zn, Al, Fe, Ni, etc., in the bath is necessary in order to form a skin, and since these metals all tend to form insoluble xanthates readily, it seems logical to assume that during spinning they momentarily react with the cellulose xanthate. This, in effect, would prohibit crystallization by producing a temporary cross-linkage between the cellulose chains.

Since no skin is formed unless considerable free alkali is present, and the ratio of alkali to bath-acid is kept within certain limits, it is probable that the acid which first penetrates the viscose stream is mostly used in neutralizing the free NaOH. This leaves the pH high enough for the metal ions, which are carried along with the acid, to react with the xanthate, thus momentarily coagulating rather than regenerating the cellulose in the skin. It can be shown that a coagulated membrane tends to diffuse NaOH out faster than it diffuses H_2SO_4 in. This would keep the pH of the skin high enough to delay xanthate decomposition while the free alkali from the core diffuses out through the skin. In the meantime, bath draft would tend to orient the skin, while the core, still being in somewhat viscous state, is less affected. Later, when the acid diffuses into the core, it is free to decompose the xanthate before the still slower-diffusing metal ions arrive to form cross-links. Since metal cellulose xanthates are formed in the skin while the cellulose chains are still in a somewhat disorganized state, the cross-links would thus prevent the chains from rotating into positions favorable for crystallization at the critical period in which they are passing from a liquid into a gel state. This would favor the formation of large numbers of crystallite nuclei. However, these nuclei and the connecting chains are still free to line up or to orient in a roughly parallel arrangement, as a result of godet stretch and tension due to shrinkage from dehyration and to bath drag, but the chains are not free to rotate around their long axis, which is a necessary condition for the growth of crystals. When the metal xanthate is later decomposed, the chains are no longer in a mobile position and hence are forced to form smaller, more fiber-like crystallites which are closely linked together by the long cellulose chains which pass from one crystallite to another to form a network structure. In other words, the metal ions in the bath have an effect upon the structure which is somewhat analogous to that of a quenching action when thermoplastic fibers are extruded or melt-spun.

This suggested mechanism is supported by the work of Moore [3], who determined the xanthate content of freshly spun filaments. Moore studied several salts and found zinc to be the most effective metal in preserving the xanthate. His analysis showed zinc cellulose xanthate to be present in the outer skin in the form of an elastic gel and he concluded that this gel membrane had considerable effect on the dehydration rate of the filaments, causing a great decrease in the speed of complete regeneration. It seems logical to assume further that this zinc xanthate would affect the type and degree of crystallization as postulated above, and that this, in turn, would affect the dye absorption.

Relationship of Structure to Fiber Properties

With a given cellulose chain length and distribution range, two major factors may be varied to alter the physical properties of a rayon fiber. These are crystallinity and orientation. It is now generally

recognized that these factors affect the physical properties of the fiber as follows.

Structure	Strength	Elongation
Good orientation	High	Low
Poor orientation	Low	High
Good crystallinity	High	Very low
Poor crystallinity	Low	High

For a strong, tough yarn, a high strength is needed, together with a high elongation. From the above facts it follows that these properties can be obtained either by combining (1) good crystallinity with poor orientation or (2) good orientation with poor crystallinity. It is obvious that (2) is a better combination than (1), since good crystallinity with poor orientation would tend to give localized areas of strain and rupture when the fiber is elongated.

A high degree of axial orientation naturally permits poor crystallinity only in the lateral direction, since good axial orientation implies a condition approaching crystallization in one direction. Axial orientation is controlled largely by the draft or degree of stretching, whereas crystallinity is controlled largely by the number of nuclei formed in the bath. The best way to produce a strong, high-elongation yarn, therefore, is to set up the filament under conditions which would hinder crystallization and at the same time provide sufficient stretch to produce the maximum degree of orientation.

Apparently the skin is formed under conditions which favor good orientation and poor crystallinity, and these conditions are enhanced by the fact that the crystalline and amorphous areas are both small. A small crystallite size enables one end of a long cellulose chain to form part of one crystallite and the other end to form part of a neighboring crystallite, with the disorganized middle portion (amorphous area) connecting the two crystalline areas. With the opposite ends of the molecule anchored in neighboring crystallites, strength is contributed to the structure, while at the same time the disorganized areas between the crystallites contribute extensibility. Furthermore, swelling and dye penetration are limited by the shortness of the connecting chain segments between the crystallites, although the total percent of amorphous areas may be relatively high.

The core, on the other hand, is formed under conditions which favor the formation of fewer nuclei and their subsequent growth to larger crystalline areas, which in turn are separated by larger amorphous areas. These larger amorphous areas allow greater swelling and dye penetration, although the total percent of amorphous areas may be no greater than that of the skin.

In the above discussion, the terms "crystalline" and "amorphous" cannot be taken too literally, for the difference between the two is probably one of degree rather than of kind. The available data could be explained by the presence of a more or less medium lateral order throughout the whole skin structure rather than by the presence of small crystallites (high order) interwoven with small amorphous areas (low order). However, regardless of the exact type of skin structure, it is significant to note that all of the strong, tough viscose rayons now being produced have a relatively thick skin (often up to 50 percent of the cross section area).

Literature Cited

1. Hall, A. J., *J. Soc. Dyers and Colourists* **45**, 99 (1929).
2. Liesegang, R., *Z. Wiss. Mikroscop.* **57**, 307 (1940).
3. Moore, C. L., *Silk and Rayon* **9**, 19, 71, 128, 181 (1935).
4. Morehead, F. F., and Sisson, W. A. Paper presented at the American Association for the Advancement of Science, Gibson Island Conference on Textiles, July 5–9, 1943. (The contents of the present paper were presented in part at this conference.)
5. Ohara, K., *Sci Papers Inst. Phys. Chem. Research* **25**, 152 (1934).
6. Preston, J. M., *J. Soc., Chem. Ind.* **50**, T199 (1931).
7. Schramek, W., and Zehmish, E., *Kolloid Beihefte* **48**, 93 (1938).
8. Schramek, W., and Helm, J., *Kolloid-Z.* **88**, 291 (1938); *Cellulosechemie* **18**, 1 (1940).

The Mechanical Properties of Textiles

II. A General Theory of Elasticity with Application to Partially Rubber-Like Substances[1]

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Contribution of the Textile Foundation and Princeton University, Frick Chemical Laboratory, Princeton, New Jersey

This paper is concerned with the deformation of a number of essentially independent molecules or molecular segments distributed statistically with respect to the distance between the ends of the molecules. They are supposed to be free to assume many configurations (as a result of thermal agitation) except at certain points which are stabilized by chemical forces to form the more or less tightly held (and thus well-defined) ends of the molecules.

The problem solved here is as follows: Given an equilibrium distribution as a function of certain parameters, and given the expression for bulk properties in terms of molecular coordinates, what is the form of the tension as a function of the elongation and the various parameters?

THE behavior of long molecules is complicated by the fact that the temperature changes the effective number of molecular segments acting independently. However, over limited temperature ranges the effective number of molecules can be treated as a constant. Several cases of a rather general nature, all containing potentials, are considered. Although they are based on quite different hypotheses, it is of interest to find that if there is no volume change they all give the following form for the dependence of tension, τ, on proportional elongation, α:

$$\tau = C\left(\alpha - \frac{1}{\alpha^2}\right),$$

for the physically important three-dimensional case. Thus, to decide between even drastically different models involves an analysis of the dependence on temperature or some similar parameter of the proportionality factor C. The above functional form has previously been derived for rubber, for which it has hitherto been established with rather severe assumptions with respect to the absence of potential energy and has been used with these assumptions in view. The wider applicability of the relationship is therefore a matter of considerable interest. In the considerations which follow the most important limitation lies in the neglect of the finite length of chains. This deficiency is significant as fibers approach their maximum extension prior to breaking.

The next two sections contain the general formulation of the problem. In a later paper of this series it is planned to consider finite chain lengths in connection with fiber structure and general notions of stress relaxation.

I. The Partition Function for Deformation

Consider any system of effectively independent segments or molecules at equilibrium such that there are $n(x, y, z)dxdydz$ whose coordinates fall in the region x to $x + dx$, y to $y + dy$, and z to $z + dz$. The first assumption (a) is that for the stresses considered those molecules having lengths lying in the region $dxdydz$ have their lengths shifted bodily into the new region x' to $x' + dx'$, y' to $y' + dy'$, z' to $z' + dz'$. Before the application of the constraint the equilibrium number of molecules for this region $dx'dy'dz'$ was $n(x', y', z')dx'dy'dz'$. Thus $n(x, y, z)dxdydz$ molecules are forced into a region which under the original equilibrium conditions held only $n(x', y', z')dx'dy'dz'$ molecules. If the ratio of these two numbers is unity, the process will require no work. If the number in the

[1] The first paper in this series, "The Mechanical Properties of Textiles, I," appeared in the September, 1945, issue of TEXTILE RESEARCH JOURNAL, page 295.

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primed region is smaller, the molecules are being forced into an inadequate region and work will be required. In the remaining case the system can be made to do work. Utilizing statistical mechanics, the exact amount of work done on the $n(x, y, z)dxdydz$ molecules (the Helmholtz free energy) is:

$$- kTn(x, y, z)dxdydz \ln \left[\frac{n(x', y', z')dx'dy'dz'}{n(x, y, z)dxdydz} \right]. \quad (1)$$

Summing this for all regions of the initial coordinates x, y, z gives the total change in the Helmholtz free energy ΔA for all molecules. Thus

$$\Delta A = - kT \int\int\int n(x, y, z) \times \ln \left[\frac{n(x', y', z')dx'dy'dz'}{n(x, y, z)dxdydz} \right] dxdydz. \quad (2)$$

The perfect gas and the electromotive force of dilute concentration cells are each examples of independent systems to which equation (2) applies. Thus ΔA for any constraint of the kind (a) is completely specified by the transformation (b),

$$x' = f_1(x, y, z); \quad y' = f_2(x, y, z),$$

and

$$z' = f_3(x, y, z), \quad (3)$$

and the density function $n(x, y, z)$ of molecules in x, y, z space. As is well known,

$$dx'dy'dz' = \begin{vmatrix} \frac{\partial x'}{\partial x} & \frac{\partial x'}{\partial y} & \frac{\partial x'}{\partial z} \\ \frac{\partial y'}{\partial x} & \frac{\partial y'}{\partial y} & \frac{\partial y'}{\partial z} \\ \frac{\partial z'}{\partial x} & \frac{\partial z'}{\partial y} & \frac{\partial z'}{\partial z} \end{vmatrix} dxdzdz \equiv Jdxdydz, \quad (4)$$

where the Jacobian, J, is defined by equation (4). Thus equation (2) can be rewritten to give

$$\Delta A = - kT \int\int\int n(x, y, z) \left[\ln \frac{n(x', y', z')J}{n(x, y, z)} \right] dxdydz. \quad (5a)$$

Substituting the transformation (b), the expression $n(x'y'z')J$ becomes a function of (x, y, z). As a result, the equality $n(x', y', z')\, J = n'(x, y, z) = n'$ is obtained. Thus equation (5) is written as a function of x, y, and z, as follows:

$$\Delta A = - kT \int\int\int n \ln \frac{n'}{n} dxdydz. \quad (5b)$$

ΔA, defined by equation (2), being a definite integral, is not a function of the variables of integration. Applying the inverse of transformation (b) to equation (2) and denoting the new variables by double primes gives

$$\Delta A = - kT \int\int\int n(x'', y'', z'') \times \ln \frac{n(x, y, z)}{n(x'', y'', z'')} dx''dy''dz''. \quad (6a)$$

Remembering that

$$dx''dy''dz'' = \frac{1}{J} dxdydz$$

and defining

$$n(x'', y'', z'') \frac{1}{J} = n''(x, y, z),$$

it is clear that ΔA becomes:

$$\Delta A = - kT \int\int\int n'' \ln \frac{n}{n''} dxdydz. \quad (6b)$$

This extends an earlier result of Wall [1], in which he was concerned with calculating $\Delta A = \Delta E - T\Delta S$ for systems in which ΔE, the change in potential energy, was zero.

Examples. Equation (2) is now applied to calculate the work done in compressing a gas from an initial volume V to a final volume V'. Before the constraint is applied the equilibrium density is the same at all points in the vessel so that

$$n(x', y', z') = n(x, y, z) \quad \text{and} \quad \frac{dx'dy'dz'}{dxdydz} = \frac{V'}{V}. \quad (7)$$

Further, the integral

$$\int\int\int n(x, y, z)dxdydz = N,$$

the total number of molecules, so that equation (2) becomes $\Delta A = - NkT \ln V'/V$, which is the well-known result obtained by the integration

$$\Delta A = - \int_V^{V'} pdV = - NkT \ln \frac{V'}{V}.$$

As a second example, equation (2) is used to calculate the formula for the elastic constants of rubber-like molecules. Following Kuhn [2], the number

$$n(x, y, z)dxdydz = N \frac{\beta^3}{\pi^{\frac{3}{2}}} e^{-\beta^2(x^2+y^2+z^2)} dxdydz \quad (8)$$

is the number of molecules whose x, y, and z com-

ponents of the vector distance between the two ends of each molecule fall in the region $dxdydz$. Integrating over all regions of x, y, and z gives the total number of molecules.

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} n(x, y, z)dxdydz = \frac{N\beta^3}{\pi^{\frac{3}{2}}}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-\beta^2(x^2+y^2+z^2)}dxdydz = N. \quad (9)$$

If it be assumed that the ratio α, of stretched to unstretched rubber, in the x direction applies to each individual molecule and that stretching involves no volume change of individual molecules, then

$$x' = \alpha x; \quad y' = \alpha y^{-\frac{1}{2}}; \quad z' = \alpha^{-\frac{1}{2}}z. \quad (10)$$

Substituting equations (8) and (10) in equation (5) gives

$$\Delta A = -kTN\frac{\beta^3}{\pi^{\frac{3}{2}}}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-\beta^2(x^2+y^2+z^2)} \times \beta^2\left[x^2(1-\alpha^2) + (y^2+z^2)\left(1-\frac{1}{\alpha}\right)\right]dxdydz = kTN\tfrac{1}{2}(\alpha^2 + 2/\alpha - 3). \quad (11)$$

Using the combined first and second laws of thermodynamics yields:

$$TdS = dE + dW, \quad (12)$$

and, by definition, $A = E - TS$. Differentiating,

$$dA = dE - TdS - SdT. \quad (13)$$

Combining equations (12) and (13) gives

$$dA = -SdT - dW. \quad (14)$$

Now in stretching rubber the work done on the system is

$$-dW = -pdV + \tau adl = -pdV + \tau l_0 a d\alpha,$$

so that substituting in equation (14) we obtain for the tension, τ, on unit cross section,

$$\frac{1}{al_0}\left(\frac{\partial A}{\partial \alpha}\right)_{T,V} = \tau. \quad (15)$$

Here l_0 and l are the overall length of the sample in the stretching direction before and after stretching, respectively. a, T, S, E, p, and V are, respectively, the cross-sectional area of the sample, the temperature, entropy, energy, pressure, and volume of the system. Now $\Delta A = A' - A$, where A', the final stretched state, depends on α, while A, the unstretched state, is independent of α.

Thus from equation (11)

$$\tau = \frac{1}{al_0}\frac{\partial \Delta A}{\partial \alpha} = \frac{NkT}{al_0}(\alpha - 1/\alpha^2) \quad (16)$$

Here N/al_0 is of course the number of effective molecules per unit volume. This is Wall's result [3]. Alternatively using $x'' = x/\alpha$, $y'' = \alpha^{\frac{1}{2}}y$, $z'' = \alpha^{\frac{1}{2}}z$, and equation (8) with equation (6) also leads to equation (16). This latter entirely equivalent procedure more closely parallels Wall's argument.

Another obvious application of this method can be made to ordinary crystals by taking x, y, and z as the three cross sections of some repeated independent unit. The unit cells may approximate independent units. The equilibrium distribution $n(x, y, z)$ for fluctuation in size of the independent unit is then required, together with the transformation (3), giving the distortion of the independent unit caused by the constraint.

If more than one type of molecule or independent unit is involved in a sample, the ΔA's for all types of units are additive and a set of transformations (3) for each type is required. The composite ΔA is then differentiated, using equation (15), to get the tension. To calculate other elastic properties than tension requires only a knowledge of the deforming transformations which such constraints impose [4]. By calculating ΔA instead of just the entropy change we are able to treat the elastic deformation of all substances. In the paragraphs that follow the deformation induced in individual molecules (or unit cells) by a macroscopic deformation is examined more closely. Thus the assumption that each molecule has its component lengths changed in the same proportion as for the macroscopic deformation is only an approximation of the truth.

II. Hypotheses Concerning the Strained Distribution

In order to calculate the dependence of the tension on the elongation and the initial distribution alone, hypotheses are required concerning the manner in which the distortion divides itself among the numerous elements that in sum are distorted to change the total length, l_0, to the value $l_0\alpha$.

In certain cases now to be considered it is possible to write the distribution function $n(x, y, z)$

as a product of three functions, each depending upon one coordinate. Thus $n(x, y, z) \equiv N\psi_x\psi_y\psi_z$. It will also be convenient to use the notation $n''(x, y, z) = N\Omega_x\Omega_y\Omega_z$. Here N is the total number of molecules and

$$\int \psi_x dx = \int \psi_y dy = \int \psi_z dz = 1,$$

where the integration is over all types of molecules. The Ω's are likewise distributions normalized to unity.

The manner in which the various x values add to give a macroscopic property can be expressed as the integral of the distribution function Ω_x multiplied into the appropriate function $\varphi(x)$. The simplest example is pure vectorial addition when $\varphi(x)$ becomes x, thus:

$$\int \Omega_x x dx = \bar{x}_0\alpha_x. \tag{17}$$

$\bar{x}_0$ is always used to designate the average contribution of a molecule (or segment) to the x component of length of a fiber before stretching and α_x is the average ratio of stretched to unstretched x component. If N_x molecules (or segments) add end to end to span the fiber in the stretched state the fiber has the stretched length $N_x\alpha_x\bar{x}_0$.

It is convenient to think next of ψ_x as an idealized standard distribution of individual molecules not necessarily attained in actual solids. The actual distribution Ω_x of the solid is then thought of as being in equilibrium with the hypothetical state, ψ_x, subject to three conditions on the distribution Ω_x:

1. The increase in free energy in going from the ideal to the actual case is a minimum.

2. The length of the solid has the macroscopically observed value.

3. There is conservation of the number of particles in passing to the actual state.

These three conditions are expressed mathematically as equations (19), (20), and (21), respectively.

Hypothesis I

By assumption (1), Ω_x is such that it minimizes the x dependent part of the Helmholtz free energy of equation (6b)—that is, of

$$A_x = -NkT\int \Omega_x \ln \frac{\psi_x}{\Omega_x} dx.$$

This corresponds to the individual molecules adjusting their length to give the lowest possible energy for a given overall elongation.

Minimizing with respect to Ω_x, the expression

$$\int \Omega_x \ln \frac{\psi_x}{\Omega_x} dx \tag{18}$$

gives

$$\int (ln\ \psi_x - \ln \Omega_x - 1)\delta\Omega_x dx = 0. \tag{19}$$

Keeping the length constant leads to the further condition

$$\int \varphi(x)\delta\Omega_x dx = 0, \tag{20}$$

while conservation of the number of molecules yields

$$\int \delta\Omega_x dx = 0. \tag{21}$$

Combining these three conditions by Lagrange's method of undetermined multipliers gives

$$\ln \psi_x - \ln \Omega_x - 1 + \nu + \mu\varphi(x) = 0 \tag{22}$$

or

$$\Omega_x = e^{\nu-1}(\psi_x e^{\mu\varphi(x)}).$$

Here ν and μ are constants to be determined. Normalizing to determine ν gives the relationship

$$\Omega_x = \frac{\psi_x e^{\mu\varphi(x)}}{\int \psi_x e^{\mu\varphi(x)} dx}. \tag{23}$$

To determine μ the mean molecular length is calculated:

$$\frac{l_0\alpha_x}{N_x} = \frac{\int \psi_x\varphi(x)e^{\mu\varphi(x)}dx}{\int \psi_x e^{\mu\varphi(x)}dx}. \tag{24}$$

The symbol l_0 is the original length of N_x independent units joined to make the total fiber length. Stretching lengthens the fiber to the value $l_0\alpha_x$.

$l_0/N_x = \bar{x}_0$ represents the ratio of these integrals when $\alpha_x = 1$. Next the Helmholtz free energy and the tension are calculated.

$$\frac{-\Delta A_x}{NkT} \equiv Y = \int \Omega_x \ln \frac{\psi}{\Omega_x} dx \tag{25}$$

$$\frac{-\Delta A_x}{NkT} = \int \frac{\psi_x e^{\mu\varphi(x)}\left[-\mu\varphi(x) + \ln \int \psi_x e^{\mu\varphi(x)}dx\right]dx}{\int \psi_x e^{\mu\varphi(x)}dx}$$

$$= \ln\left(\int \psi_x e^{\mu\varphi(x)}dx\right) - \bar{x}_0\mu\alpha_x. \tag{26}$$

Further:

$$\frac{\partial Y}{\partial \mu} = \frac{\int \varphi(x)\psi_x e^{\mu\varphi(x)}dx}{\int \psi_x e^{\mu\varphi(x)}dx} - \bar{x}_0\alpha_x - \bar{x}_0\mu\frac{\partial \alpha_x}{\partial \mu}$$

$$= -\bar{x}_0\mu\frac{\partial \alpha_x}{\partial \mu}, \tag{27}$$

whence

$$Y = -\int \bar{x}_0\mu d\alpha_x, \tag{28}$$

where μ is evaluated from

$$l_0\alpha_x = N\frac{\int \varphi(x)\psi_x e^{\mu\varphi(x)}dx}{\int \psi_x e^{\mu\varphi(x)}dx}. \tag{29}$$

Now if the contribution to tension due to distortion in the x direction be indicated by τ_x, then

$$\tau_x = \frac{1}{al_0}\frac{\partial \Delta A_x}{\partial \alpha_x} = -\frac{NkT}{al_0}\frac{\partial Y}{\partial \alpha_x} = \frac{NkT}{al_0}\bar{x}_0\mu. \tag{30}$$

Two interpretations of $\varphi(x)$ are to be considered. In Hypothesis I*a* the N_x chains are joined end to end, overlapping occurs, and the extensions, if of different sign, work against each other. In this case it must be supposed that an internal pressure keeps the overall length from dropping to zero. For this case

$$\varphi(x) = x.$$

On the other hand, according to Hypothesis I*b*, each molecule occupies as much space as the value of its x; then it is the absolute value that must be used in averaging x,

$$\varphi(x) = |x|.$$

Hypothesis II

The stretched distribution Ω_x is considered to be the distribution $1/\alpha\,\Omega'_{x/\alpha}$ where Ω'_x is the actual unstretched distribution. The meaning of this assumption is that every x in the unstrained state becomes αx in the strained state. The subscript x on α is omitted until it is required for clarity. This equality of all microscopic strains to the macroscopic strain is reasonable if the three-dimensional network hinders immediate molecular rearrangement. Such a rearrangement would lead to a lower free energy. The change of free energy in passing from the ideal to the stretched state is:

$$-\frac{\Delta A_x}{NkT} = Y = \int_{-\infty}^{\infty} 1/\alpha\,\Omega'_{x/\alpha}\ln\frac{\psi_x}{1/\alpha\,\Omega'_{x/\alpha}}dx. \tag{31}$$

In Hypothesis II*a*, when $\varphi(x) = x$, if the actual unstretched distribution Ω'_x were taken equal to ψ^x it would lead to the impossible result of zero extension in the case of rubber, since

$$\int_{-\infty}^{\infty} x\psi_x dx = 0.$$

It is possible, however, to assume that the rubber in its unstrained state would in response to an internal pressure assume some equilibrium distribution Ω'_x unsymmetrical with respect to plus and minus x. As an example, it will be assumed that the actual initial distribution, Ω'_x, is to be calculated from the *ideal* distribution, ψ_x, by minimizing the free energy exactly as was done under Hypothesis I. Different from Hypothesis I, however, in this case, Hypothesis II*a*, the *actual* stretched distribution will be obtained from the actual unstretched distribution by assuming that the microscopic stress is equal to the macroscopic—that is, $\Omega_x = 1/\alpha\,\Omega'_{x/\alpha}$.

In the special case, Hypothesis II*b*, when the length of the solid can be taken as the sum of the absolute value $|x|$ of the individual molecules it is reasonable to assume that the actual initial state Ω'_x may be taken as the ideal state ψ_x. Thus

$$-\frac{\Delta A_x}{NkT} = Y = \int_{-\infty}^{\infty} 1/\alpha\,\psi_{x/\alpha}\ln\frac{\psi_x}{1/\alpha\,\psi_{x/\alpha}}dx. \tag{32}$$

This is the customary treatment of elasticity in rubber and yields the three-dimensional result

$$\tau = \frac{NkT}{al_0}(\alpha - (1/\alpha)^2) \tag{33}$$

as we have already seen in equation (16), where the usual value of ψ_x was assumed.

III. Tension as a Function of the Initial Distribution and External Parameters

To proceed further, an assumption concerning the initial distribution must be made. For the purposes of many problems, the assumption of infinitely long chains is not available. However, for the purpose of illustrating the method set forth above, and in order to illuminate the specific problem of rubber-like substances with a potential energy tending to keep the molecules extended,

the following distribution is considered:

$$\psi_x = \frac{e^{-(px^2+qx)}}{\int_{-\infty}^{\infty} e^{-(px^2+qx)}dx}, \tag{34}$$

which allows integration over the limits $-\infty$ to ∞. Substituting the distribution function of equation (34) into equation (24) gives:

$$\frac{\alpha l_0}{N_x} = \frac{\int \varphi(x) e^{-(px^2+qx-\mu\varphi(x))}dx}{\int e^{-(px^2+qx-\mu\varphi(x))}dx}. \tag{35}$$

The Hypothesis I*a*, where $\varphi(x) = x$, gives

$$\frac{\alpha l_0}{N_x} = \bar{x}_0\alpha = \frac{\mu - q}{2p},$$

as is seen from the integrals in Appendix (*a*). So that:

$$2p\bar{x}_0\alpha + q = \mu. \tag{36}$$

Using the relationship in equation (30) gives:

$$\tau_x = \bar{x}_0 \frac{kTN}{al_0}(2p\bar{x}_0\alpha + q). \tag{37}$$

Now, according to the earlier assumption about Hypothesis I*a*, there is an internal pressure which balances the calculated pressure of the unstretched state. This has the value

$$\tau_{\alpha=1} = \frac{\bar{x}_0 kTN}{al_0}(2px_0 + q).$$

The external pressure, τ_e, is thus obtained by subtracting from the above total pressure τ_x the internal pressure $\tau_{\alpha=1}$.

$$\tau_e = \tau_x - \tau_{\alpha=1} = \frac{kTN}{al_0}[\bar{x}_0 2p(\alpha - 1)]. \tag{38}$$

For the next case, Hypothesis I*b*, $\varphi(x) = |x|$,

$$\alpha l_0 = N_x \frac{\int |x| e^{-(px^2+qx-\mu|x|)}dx}{\int e^{-(px^2+qx-\mu|x|)}dx}. \tag{39}$$

This case cannot be directly solved for τ_x as a function of α; however, it is solved for α as a function of τ_x in Appendix (*b*).

The Hypothesis II*a*, to be discussed next, is the type of proportional elongation where $\varphi(x) = x$ and Hypothesis II holds. According to Hypothesis II*a*, the ideal distribution ψ_x rearranges to the actual unstretched distribution Ω'_x in such a way as to minimize the energy but still conserve the length and the number of particles. Thus Ω'_x in general differs from ψ_x.

Referring back to equation (25), it follows that the change in free energy for passage from the ideal to the actual state is given by:

$$\frac{-\Delta A_x}{NkT} = Y = \int_{-\infty}^{\infty} 1/\alpha\, \Omega'_{x/\alpha} \ln \frac{\psi_x}{1/\alpha\, \Omega'_{x/\alpha}} dx.$$

According to equation (36), when $\alpha = 1$, $\mu = 2p\bar{x}_0 + q$. Thus, according to equation (23),

$$\Omega_x = 1/\alpha\, \Omega'_{x/\alpha} = \frac{\psi_{x/\alpha} e^{(2p\bar{x}_0+q)x/\alpha}}{\int \psi_{x/\alpha} e^{(2p\bar{x}_0+q)x/\alpha}dx}; \tag{40}$$

$$Y = \int \frac{e^{-[p(x^2/\alpha^2)-2p\bar{x}_0(x/\alpha)]}}{\int e^{-[p(x^2/\alpha^2)-2p\bar{x}_0(x/\alpha)]}dx} \times \left\{ -\ln\left[\frac{\int e^{-(px^2+qx)}dx}{\int e^{-[p(x^2/\alpha^2)-2p\bar{x}_0]x/\alpha}dx}\right] - \left[px^2 - \frac{p^2}{\alpha^2}x^2 + qx + \frac{p\bar{x}_0}{\alpha}x\right]\right\} dx$$

$$= \ln\alpha - \ln\frac{\int e^{-(px^2+qx)}dx}{\int e^{-(px^2-2px_0x)}dx} - p(\alpha^2 - 1)\int x^2\Omega'_x dx - (q\alpha + p\bar{x}_0)\int x\Omega'_x dx;$$

$$Y = \ln\alpha - \ln\int (e^{-(px^2+qx)}dx + \ln\int e^{-(px^2-2p\bar{x}_0x)}dx - p(\alpha^2 - 1)\left(\frac{1}{2p} + \bar{x}_0^2\right) - (q\alpha + p\bar{x}_0)x_0$$

$$\tau_x = -\frac{NkT}{al_0}\frac{\partial Y}{\partial\alpha} = -\frac{NkT}{al_0}\left[\frac{1}{\alpha} - p\left(\frac{1}{p} + 2\bar{x}_0^2\right)\alpha - q\bar{x}_0\right]. \tag{41}$$

Setting $\alpha = 1$ in equation (41) for τ_x yields the non-zero expression $\tau_{\alpha=1}$ for the internal pressure.

$$\tau_{\alpha=1} = -\frac{NkT}{al_0}(2\bar{x}_0^2 p - q\bar{x}_0);$$

$$\tau_e = \tau_x - \tau_{\alpha=1}$$

$$= \frac{NkT}{al_0}\left[\frac{1-\alpha}{\alpha} - (1+2\bar{x}_0^2 p)(\alpha-1)\right].$$

Next, some specific problems will be treated according to the Hypothesis II*b*. As before,

$$\psi_x = \frac{e^{-(px^2+qx)}}{\int e^{-(px^2+qx)}dx},$$

and, furthermore, $\varphi(x) = |x|$. The ideal state ψ_x is taken to be the actual unstretched state. Then

$$Y = N\int_{-\infty}^{\infty} 1/\alpha\,\psi_{x/\alpha} \ln \frac{\psi_x}{1/\alpha\,\psi_{x/\alpha}}\,dx,$$

$$1/\alpha\psi_{x/\alpha} = \frac{e^{-[(p/\alpha^2)x^2+qx/\alpha]}}{\alpha\int e^{-[px^2/\alpha^2+q(x/\alpha)]}\frac{dx}{\alpha}},$$

and

$$Y = \frac{\int_{-\infty}^{\infty} e^{-[(p/\alpha^2)x^2+qx/\alpha]}}{\int e^{-[(p/\alpha^2)x^2+qx/\alpha]}dx}$$

$$\left\{\ln\alpha - \left[\frac{p}{\alpha^2}(\alpha^2-1)x^2 + \frac{q}{\alpha}(\alpha-1)x\right]\right\}dx$$

$$= \ln\alpha - (\alpha^2-1)p\int_{-\infty}^{\infty}\frac{x^2}{\alpha^2}\psi_{x/\alpha}dx$$

$$- g(\alpha-1)\int_{-\infty}^{\infty} x/\alpha\,\psi_{x/\alpha}dx. \quad (42)$$

The above integrals are independent of α, because of the infinite limits, and are easily evaluated:

$$Y = \ln\alpha - \tfrac{1}{2}(\alpha^2-1)\left(1+\frac{q^2}{2p}\right).$$

Hence,

$$\tau = -\frac{NkT}{a_0 l_0}\frac{\partial Y}{\partial\alpha} = \left(\frac{1}{\alpha}+1+\frac{q^2}{2p}\right)(\alpha-1).$$

This particular case is capable of generalization to a ψ_x of the following type:

$$\psi_x = \frac{e^{S_0+S_1x+\cdots S_nx^n+\cdots}}{\int e^{S_0+S_1x+\cdots S_nx^n+\cdots}dx}, \quad (43)$$

and

$$1/\alpha\,\psi_{x/\alpha} = \frac{e^{S_0+S_1x/\alpha+\cdots S_nx^n/\alpha^n+\cdots}}{\int e^{S_0+S_1x/\alpha+\cdots S_nx^n/\alpha^n+\cdots}dx},$$

because

$$Y = \ln\alpha - \sum^n(\alpha^n-1)S_n\int_{-\infty}^{\infty}\psi_{x/\alpha}\left(\frac{x}{\alpha}\right)^n\frac{dx}{\alpha}$$

$$= \ln\alpha - \sum^n(\alpha^n-1)S_n\int_{-\infty}^{\infty}\psi_x x^n dx.$$

Thus the integrals are all independent of α, and although they are not integrable, they can be absorbed into S_n and the α dependence is established. The integrations are necessary when the temperature dependence of the tension is in question.

It should be remarked that the assumption

$$\Omega_x = 1/\alpha\,\psi_{x/\alpha} \quad (44)$$

is necessary and sufficient to establish the hypothesis of proportional elongation of each x to αx.

Because

$$\int_{-\infty}^{\infty}\Omega_x|x|^n dx = \alpha^n\int_{-\infty}^{\infty}\psi_{x/\alpha}\left(\frac{|x|}{\alpha}\right)^n\frac{dx}{\alpha}$$

$$= \alpha^n\int_{-\infty}^{\infty}\psi_x|x|^n dx,$$

the average of any power, n, of x in the stretched state is α^n times its value in the unstretched state. This can be true only if each x becomes αx on elongation.

Collecting these results gives for:

Hypothesis I, where ΔA_x is minimized and

(*a*) $\varphi(x) = x$, $\tau_e = \dfrac{kTN}{al_0}2x_0^2 p(\alpha-1)$;

(*b*) $\varphi(x) = |x|$, τ_e solved for implicitly.

Hypotheses II, where microscopic strains equal macroscopic ones, and

(*a*) $\varphi(x) = x$,

$$\tau_e = \frac{kTN}{al_0}\left(\frac{1}{\alpha}+1+2x_0^2 p\right)(\alpha-1);$$

(*b*) $\varphi(x) = |x|$,

$$\tau_e = \frac{kTN}{al_0}\left(\frac{1}{\alpha}+1+\frac{q^2}{2p}\right)(\alpha-1).$$

(45)

The generalization of these results to three isotropic isovoluminal independent dimensions proceeds as follows:

$$\Delta A_{xyz} = \Delta A_x + \Delta A_y + \Delta A_z.$$

Also,

$$\frac{\partial\Delta A_{x,y,z}}{\partial\alpha_x} = \frac{\partial\Delta A_x}{\partial\alpha_x} + \frac{\partial\Delta A_y}{\partial\alpha_y}\frac{\partial\alpha_y}{\partial\alpha_x} + \frac{\partial\Delta A_z}{\partial\alpha_z}\frac{\partial\alpha_z}{\partial\alpha_x}.$$

Assuming no volume change upon stretching,

$$\alpha_x\alpha_y\alpha_z = 1, \quad \alpha_y = \alpha_z, \quad \alpha_y = \alpha_z = \frac{1}{\sqrt{\alpha_x}};$$

then,

$$\frac{\partial \Delta A_{x,y,z}}{\partial \alpha_x} = \frac{\partial \Delta A_x}{\partial \alpha_x} + 2\frac{\partial \Delta A_z}{\partial \alpha_y}\frac{\partial \alpha_y}{\partial \alpha_x}$$

$$= \frac{\partial \Delta A_x}{\partial \alpha} - \frac{\partial \Delta A_x(1/\sqrt{\alpha_x})}{\partial(\alpha_x^{-\frac{1}{2}})}\frac{1}{\alpha^{\frac{3}{2}}}$$

$$= \left\{\tau_x(\alpha_x) - \frac{\tau_x(\alpha_x^{-\frac{1}{2}})}{\alpha^{\frac{3}{2}}}\right\} a l_0. \qquad (46)$$

The results for three dimensions, for isotropic systems, are:

Hypothesis I:

(a) $$\tau_e = \frac{kTN}{al_0} 2\bar{x}_0^2 p \left(\alpha - \frac{1}{\alpha^2}\right);$$

(b) (probably) $$\tau_e = \frac{kTN}{al_0}\frac{q^2}{2p}\left(\alpha - \frac{1}{\alpha^2}\right).$$

Hypothesis II:

(a) $$\tau_e = \frac{kTN}{al_0}(1 + 2\bar{x}_0^2 p)\left(\alpha - \frac{1}{\alpha^2}\right);$$

(b) $$\tau_e = \frac{kTN}{al_0}\left(1 + \frac{q^2}{2p}\right)\left(\alpha - \frac{1}{\alpha^2}\right).$$

It is of interest to note that all of these functions have the same form in α, which is also the form found for rubber-like elasticity:

$$\text{Tension} = C\left(\alpha - \frac{1}{\alpha^2}\right). \quad \text{[See equation (40).]}$$

IV. Tension as a Function of Molecular Parameters

If a molecular potential of the form

$$\epsilon = \gamma(x - \delta)^2$$

is assumed where δ is a displacement of the center of potential and the Gaussian degeneracy for infinite chains,

$$\sigma_x = e^{-\beta^2 x^2},$$

is assumed, then

$$\sigma_x e^{-(\epsilon/kT)} = e^{-px^2 + qx - (\gamma\delta^2/kT)},$$

and thus $p = \beta^2 + \gamma/kT$;

$$q = \frac{2\delta\gamma}{kT}; \quad l_0 = N_x\bar{x}_0.$$

The constant factor $e^{-(\gamma\delta^2/kT)}$ disappears in the normalized distribution function and can therefore be neglected.

The C in equation (40) for the tension becomes:

Hypothesis I*a*:

$$\frac{2kTN\bar{x}_0^2}{al_0}\left(\beta^2 + \frac{\gamma}{kT}\right);$$

Hypothesis I*b* (assumed):

$$\frac{2N\delta^2\gamma^2}{al_0kT\left(\beta^2 + \frac{\gamma}{kT}\right)};$$

Hypothesis II*a*:

$$\frac{kTN}{al_0}\left[(1 + 2x_0^2\beta^2) + \frac{2\bar{x}_0^2\gamma}{kT}\right];$$

Hypothesis II*b*:

$$\frac{N}{al_0}\left(kT + \frac{2\delta^2\gamma^2}{\beta^2 kT + \gamma}\right).$$

To summarize, Hypothesis I*a*, C is a linear function of T, Hypothesis I*b* is the reciprocal of a linear function, Hypothesis II*a* is again linear, and Hypothesis II*b* is of the form $T + a/T + b$. All of these functions become purely proportional to T when the potential is negligible (one vanishes), and independent of T when the potential is very sharp.

The curve for Hypothesis II*b* is the only one to show an inversion in the tension with temperature. The second derivative is positive at the inversion point, so that a minimum occurs at

$$T = \frac{\gamma}{k\beta}\left(\sqrt{2}\delta - \frac{1}{\beta}\right).$$

It is not anticipated that this minimum always would be physically important, as it requires $\sqrt{2}a > -1/\beta$, which may seldom be the case.

The Hypothesis II*b* was found by Wall for the case of no potential. There would be, however, no way to distinguish this result, experimentally, from Hypothesis II*a* in the case without potential. In this case, Hypothesis II*a*, however, no simple proportion between tension and number of links exists.

With respect to choosing among the four solutions for a particular case, such as that of rubber, it is apparent that the equilibrium cases, Hypotheses I*a* and I*b* (assumed), are obviously not possible in a firmly cross-linked structure.

The above results bridge the gap between theories of rubber elasticity and the elastic theories of ordinary crystals. As additional necessary data

on fiber elasticity become available, the appropriate logical extensions of the methods here presented will be developed.

Appendix (a)

Evaluation of the integrals:

$$I = \int e^{-(px^2+qx)}dx,$$

completing the square $a^2 = p$, $2ab = q$, $b^2 = \frac{q^2}{4p}$.

$$I = e^{q^2/4p}\int_{-\infty}^{\infty} e^{-(ax+b)^2}dx,$$

$$ax + b = y, \quad x = \frac{y-b}{a}.$$

$$I = \frac{e^{q^2/4p}}{a}\int_{-\infty}^{\infty} e^{-y^2}dy = e^{q^2/4p}\sqrt{\frac{\pi}{p}}.$$

$$I_x = \int xe^{-(px^2+qx)}dx = e^{q^2/4p}\int \frac{y-b}{a}e^{-y^2}\frac{dy}{a}$$

$$= -\frac{b}{a}I = -\frac{q}{2p}I.$$

$$I_x^2 = \int x^2 e^{-(px^2+qx)}dx$$

$$= e^{q^2/4p}\int \frac{y^2 - 2by + b^2}{a^2}e^{-y^2}dy$$

$$= \left(\frac{1}{2a^2} + \frac{b^2}{a^2}\right)I = \left(\frac{1}{2p} + \frac{q^2}{4p^2}\right)I.$$

Appendix (b)

Evaluation of the integrals for extension in Hypothesis Ib where $\varphi(x) = |x|$*:*

$$\int_{-\infty}^{\infty}\psi_x e^{\mu|x|}dx = \int_0^{\infty}\psi_x e^{\mu x} + \int_{-\infty}^{0}\psi_x e^{-\mu x}dx$$

$$= \int_0^{\infty}\psi_x e^{\mu x}dx + \int_0^{\infty}\psi_{(-x)}e^{\mu x}dx = \int_0^{\infty} e^{\mu x}\Psi dx,$$

where $\Psi = \psi_x + \psi_{-x}$. Similarly,

$$\int_{-\infty}^{\infty}|x|\psi_x dx = \int_0^{\infty} x\Psi dx$$

and

$$\int_{-\infty}^{\infty}|x|e^{\mu|x|}\psi_x dx = \int_0^{\infty} xe^{\mu x}\Psi dx.$$

Now

$$G(q) = \int_0^{\infty} e^{-(px^2+qx)}dx$$

$$= \left(\frac{\sqrt{\pi}}{2} - \frac{\sqrt{\pi}}{2}Erf\left(\frac{q}{2\sqrt{p}}\right)\right)\frac{e^{q^2/4p}}{\sqrt{p}}$$

and

$$G_x(q) = \int_0^{\infty} xe^{-(px^2+qx)}dx = -\frac{1}{2p}[qG(q) + 1],$$

where $Erf(x)$ is the tabulated probability integral

$$\frac{2}{\sqrt{\pi}}\int_0^x e^{-x^2}dx.$$

The equation between μ and α is

$$\alpha_x = \frac{\int_0^{\infty} xe^{\mu x}\Psi dx}{\left(\int_0^{\infty} x\Psi dx\right)\left(\int_0^{\infty} e^{\mu x}\Psi dx\right)}$$

or

$$\alpha_x = \frac{G_x(q-\mu) + G_x(-q-\mu)}{(G_x(q) + G_x(-q))(G(q-\mu) + G(-q-\mu))},$$

which, with the earlier results,

$$\tau_x = \frac{NkT\mu}{al_0} \quad \text{or} \quad \mu = \frac{al_0\tau_x}{NkT},$$

gives α_x as a function of τ_x.

Literature Cited

1. Wall, F. T., *J. Chem. Phys.* **10**, 485 (1942).
2. Kuhn, W., *Kolloid-Z.* **68**, 2 (1934).
3. Wall, F. T., *loc. cit.*, and other papers.
   Meyer, K. H., Von Susich, G., and Valko, E., *Kolloid-Z.* **59**, 208 (1932).
   Guth, E., and Mark, H., *Monats Chem.* **65**, 93 (1934), and later papers.
   Kuhn, W., *Kolloid-Z.* **76**, 258 (1936).
   Treloar, L. R. G., *Trans. Faraday Soc.* **39**, 36 (1943).
4. Love, A. E. H., "The Mathematical Theory of Elasticity," Cambridge, Eng., The University Press, 1892–93 (4th Ed., 1927).
   Treloar, L. R. G., *Trans. Farad. Soc.* **39**, 241 (1943).

Fiber and Spinning Properties of Cotton at Progressive Stages of Development

Earl E. Berkley[1]

Summary

The structural and physical properties of cotton fibers at progressive stages of biological development were studied with respect to induced effects on fiber and spinning properties. Two varieties of American Upland cotton, Rowden 40-2088 and Delfos (Missdel) 4, were used in the spinning tests. Another American Upland, Mexican Big Boll, and one variety of American-Egyptian cotton, Pima, were used in the fiber strength and structure tests.

Flowers were tagged and the bolls collected at frequent intervals, beginning at about 20 days after flowering and continuing to maturity.

The x-ray angle, fiber strength, length, fineness, and percentage of thick-walled fibers were determined for two series each of Rowden 40-2088 and Delfos 4, three series of Mexican Big Boll, and one of Pima. Cross-sectional studies were made on one series each of Rowden and Mexican Big Boll cottons.

The x-ray angles fluctuated somewhat from sample to sample until about the thirty-fifth day, after which they decreased gradually.

The percentage of thick-walled fibers increased rapidly until about the thirty-fifth day, after which it increased more gradually.

The fiber weight per inch increased somewhat rapidly until about the fortieth day, after which it increased very slowly or remained essentially constant.

In these samples there was a relationship between the percentage of thick-walled fibers and the fiber strength, and also between the fiber weight per inch and the fiber strength.

Spinning tests were made on the 30-day and on the open-boll samples from one series and the 35-day and open-boll samples of another series of Rowden and Delfos cottons, respectively.

The yarn strengths, the yarn appearance, and the tire-cord strengths were improved by additional cell-wall thickening in the fibers beyond that at 35 days. It might be stated, however, that the 30-day- and 35-day-old samples gave relatively good yarn strengths, which were, for the most part, essentially those to be expected from the fiber properties.

The usage of the terms "maturity" and "immaturity" to designate degree of cell-wall development does not distinguish between thin-walled fibers caused by hereditary factors or stressed condition and real immaturity due to arrested development. The use of "percent thick-walled fibers" may be less objectionable and is used here in lieu of a more adequate terminology, which must be derived from experimental data.

General Background

The importance of thin-walled fibers, so-called "immaturity" in relation to the spinning quality of cotton, has been recognized by Bowman [10], Watt [23], Balls [4], Pearson [16], and others [1]. The term "immaturity" as it has been used in commerce refers to the percent of fibers which, after swelling in 18-percent caustic, have a wall thickness of less than one-half the diameter of the lumen. Conversely, the term "maturity" has frequently been used in commercial trade journals or reports to refer to the percent of fibers with thick walls—that is, fibers with wall thickness equal to or greater than one-half the diameter of the lumen in swollen fibers. Unfortunately, this terminology does not provide for distinguishing thick- or thin-wall development that is due to physiological immaturity and that which is due to other factors—heredity, for example. Thus, thin-walled fibers that are characteristic of certain varieties, those that are present on the chalazal cap of nearly all seeds of all varieties, and those that are fully mature biologically but are very thin-walled because of water stress or inadequate nutrition during secondary development would be confused with thin-walled fibers that had not been allowed to complete secondary wall formation. Strictly speaking, only the latter can be classified as immature.

A less objectionable terminology appears to be "percent of thin-walled or thick-walled fibers." In

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using these terms, however, it should be remembered that a more accurate terminology is needed since the present method of determining and reporting the percent of "thin-walled" or "thick-walled" fibers is based not on actual wall thickness but only on an arbitrary ratio of lumen diameter to wall thickness. Thus a Sea Island cotton fiber that might be placed in the "thick-walled" category might have a thinner wall than a "thin-walled" fiber from a coarse Upland variety. Possibly the term "wall development index" might be an improvement if it were definitely known what kind of an index would be most useful. The observations of Pearson [17] and Harrison [16] have indicated that both unusually large thick-walled and thin-walled fibers may be troublesome in causing rough or neppy yarns. It seems evident that much research is needed for developing rapid methods of determining fiber size and cell-wall development and for putting such measurements to practical use.

It is indicated by the observations of Clegg [11, 12, 13, 20], Pearson [17, 18, 19], Gulati and Ahmad [15] that cotton technologists and spinners are, in general, agreed that in the same sample the individual thin-walled fibers are weaker in tensile strength than the thick-walled fibers and that a rougher yarn is produced from cottons containing a preponderance of the thin-walled types. In general, although there is some disagreement in the literature, it has been found that thin-walled fibers produce relatively strong yarns, particularly at the higher counts [11, 12, 13, 14]. Textile finishers complain, however, of the lack of uniformity in the dyeing of samples containing large percentages of thin-walled fibers.

Cotton bolls that are damaged by frost or by insects or those that open prematurely because of mineral deficiencies, diseases of the plants, or injury to the foliage, stem, or roots usually contain much higher percentages of thin-walled fibers than those not affected by such factors. It is also indicated that certain varieties of cotton which have large numbers of seeds per boll may produce motes with long but very thin-walled fibers [3].

Samples of cotton containing 50 percent or more of so-called "immature" fibers frequently occur in the last picking or in sledded cotton from the high plains of Texas and Oklahoma where frost occurs before the plant dies, and in the irrigated region where varieties of indeterminate growth are common. In some areas where the cotton bolls are "snapped" or "sledded," many immature bolls are harvested. Physiologically immature or thin-walled fibers also appear to be abundant in certain regions of Russia where the growing season is relatively short [14, 21, 22]. Although there is considerable information in the literature concerning the effects of thin-walled fibers on spinning quality, little or no attempt has been made to control the other variables, such as fiber length, cell-wall diameter, and spiral structure, while studying cell-wall thickness.

The data presented here were obtained for the purpose of comparing the fiber properties and spinning value of cottons at different stages of cell-wall development. An attempt was made to eliminate the variables—fiber length, cell-wall diameter, structure, etc. In bolls which develop simultaneously the fiber length and diameter should be constant, since these are determined before extensive deposition takes place. It is understood, however, that fibers of different ages show differential shrinkage [7] and that in the measuring process very thin-walled fibers may be extended to their full length more readily than thick-walled fibers [9]. These discrepancies should, however, tend to compensate each other.

Materials and Methods

The fiber properties of three varieties of American Upland cotton, Mexican Big Boll, Rowden 40-2088, and Delfos (Missdel) 4, and an American-Egyptian cotton, Pima, were studied, and two varieties, Rowden 40-2088 and Delfos (Missdel) 4, of the American Upland type were spun. These cottons were grown at Raleigh, North Carolina,[2] in 1937, 1938, and 1939. The age of the bolls was determined from tags which were put on the flowers on the day of opening. For the spinning tests several thousand flowers were tagged on or about July 20, 1939 (Series I), and again on July 26 (Series II). In the first series, because there were not enough bolls from flowers tagged in one day, bolls set on July 19–21, inclusive, were used.

The green bolls were opened by hand in the laboratory and the locks placed on trays to dry. The trays were placed in front of a fan which blew air over a hot plate. They were turned twice daily until dry. Because of the large quantity and the nature of the bolls which were dried for the spinning tests,

[2] These cotton samples were produced under the supervision of Dr. Thomas Kerr, employed jointly by the Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, and the North Carolina Agricultural Experiment Station.

it is possible that some small damage was sustained. The dried samples were mixed and ginned either by hand, or, in the case of the spinning samples, on a small saw gin. The structural studies were made by the x-ray method described by Berkley and Woodyard [8].

The classification, spinning, and certain fiber tests were run according to the standard practices of the Cotton and Fiber Branch, Office of Marketing Services.[3]

Results

Fiber Properties. The tensile strength of the young fiber 23 to 28 days old was only about 60,000 pounds per square inch, on the average. The fiber strength increased more or less rapidly until about the thirty-fifth day and gradually thereafter (Figure 1), whereas the fiber weight (μ grams/inch) increased until about the fortieth day, with little change thereafter (Figure 2). The percent of thick-walled fibers (Figure 2) and, to a certain extent, the x-ray angles (Figure 1) fluctuated until about the fortieth day, with slight changes thereafter.

The lengths of the fibers in the spinning series were measured by the length array method and the upper quartile fiber lengths are given in Table I. The fiber length was greater at 30 and 35 days for Rowden, Series I and II, respectively, and at 35 days, for Delfos, Series I, than in the open-boll samples. This was undoubtedly due to the technique used since the fibers at the early stages of development can be more readily extended to their full length than the stiffer thick-walled fibers.

The orientation of the cellulose in the fibers fluctuated less in general with increased age and a

[3] Under the general supervision of Carl Robinson.

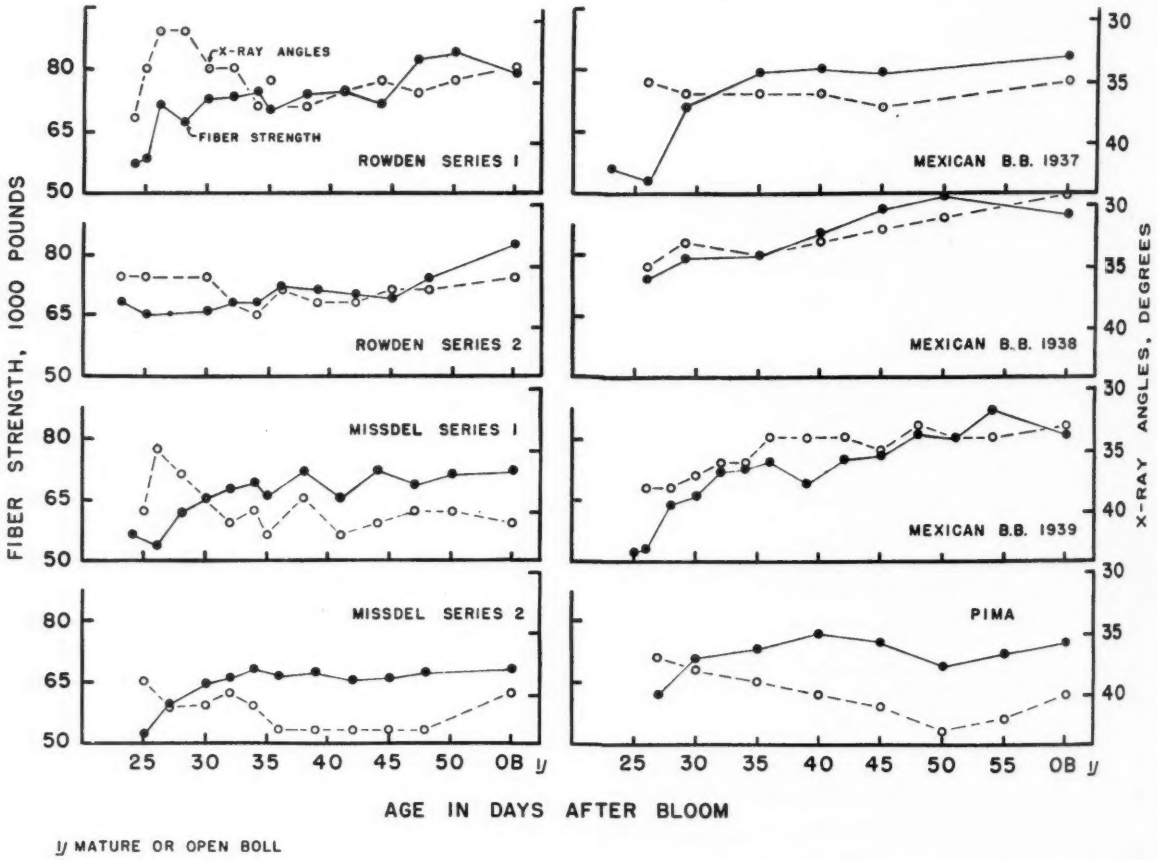

FIG. 1. *Fiber strength and x-ray angles at progressive stages of development of cotton. The x-ray angles and the Chandler fiber bundle strength (on the ordinate) and the age of the fiber in days after bloom (on the abscissa). These comprise the two series of samples from each of Rowden 40-2088 and Delfos (Missdel) 4 from which the spinning samples were taken, and three from Mexican Big Boll and one from Pima cotton on which fiber tests only were made. Note that the scales for the x-ray angles are inverted.*

slightly better alignment was observed at maturity. The fiber strength increased as the cell walls increased in thickness. As the proportion of thick-walled fibers increased beyond 80 percent, the fiber strength increased more or less rapidly in the Rowden and Mexican Big Boll cottons. It is interesting to note that the variety Delfos contained more than 20 percent thin-walled fibers even in the open-boll samples. The samples from Pima cotton were confined to one series; therefore, there were only a few individual measurements, but they follow, in general, the same trend as those from the Upland varieties.

The differences in weight per unit length of the fiber shown in Figure 2 are due principally to age or state of development of the fiber rather than to growth conditions or variety differences. Here again the strength increased more or less rapidly until the fiber weight reached about 3 micrograms per inch, after which there was little change until it exceeded 5 micrograms. As the fiber weight increased beyond 5 micrograms per inch, the fiber strength increased more rapidly.

The cross sections of the Rowden, Series I, samples (Figure 3) show the relative thickness of the cell walls at the different stages of development. The fiber walls, during the primary wall stage, are estimated to be in the neighborhood of 0.2 to 0.4 μ thick [2]. At the age of 28 days, they were found to average 1.2 μ; at 35 days, 2.9 μ; whereas at 30 days, just as the bolls were opening, they reached 4.4 μ. The tensile strength of fiber bundles and the yarn strength increased comparatively little after 35 days, whereas the thickness of the fibers increased appreciably. Sections cut from other series of samples showed the same general trend in cell-wall development with increase in the age of fibers.

Spinning Tests. The classification as to grade and staple length, percent waste, the skein strength of the 22s, 36s, and 50s yarn, and the strength and

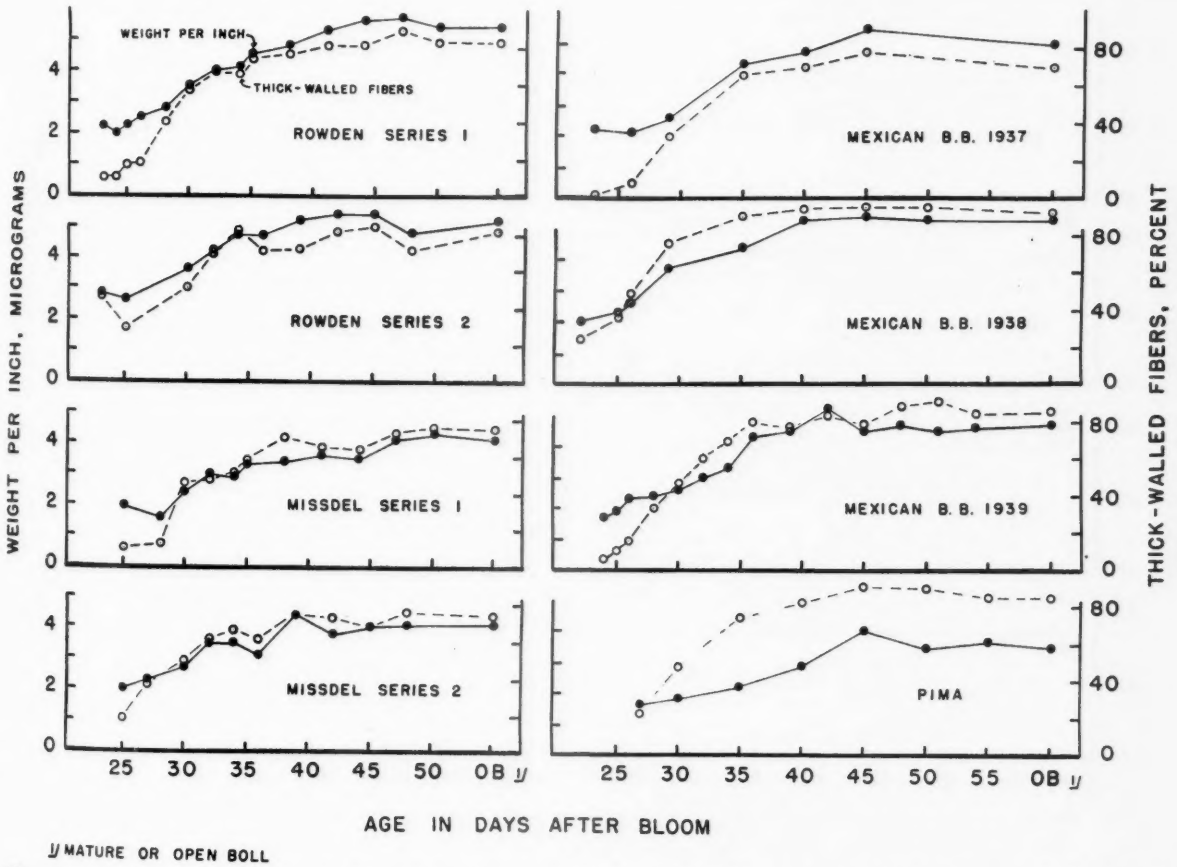

FIG. 2. *Fineness, weight per inch, and percentage of thick-walled fibers at progressive stages of development of cotton. The percent of thick-walled fibers and fiber fineness (μ grams/inch) on the ordinate and the age of the fiber in days after bloom on the abscissa. These values were taken from the same samples as those in Figure 1.*

TABLE I. FIBER AND SPINNING DATA FOR TWO VARIETIES OF COTTON COLLECTED AT VARIOUS STAGES OF BIOLOGICAL DEVELOPMENT
(Cotton grown at Raleigh, N. C., 1939)

Age in days after bloom	Variety	Classers' grade	Staple length (in.)	Total waste (%)	Yarn skein strength			Yarn imperfections				Yarn appearance		Cord strength (lbs.)	Elongation of cord at 10% load (%)	Fiber length		Fiber fineness (μg./in.)	Thick-walled fibers (%)	Fiber strength (1,000 lbs./sq. in.)	X-ray angles (degrees)
								Seed-coat fragments		Neps		Grade									
					22s (lbs.)	36s (lbs.)	50s (lbs.)	22s[2] (no.)	50s (no.)	22s (no.)	50s (no.)	22s	50s			U.Q.L. (in.)	M.L. (in.)				
35	Rowden Ser. I	GM	1	8.15	93.04	47.40	30.74	128	82	44	32	C	C −	15.0	12.38	1.152	1.001	4.5	73.4	70.3	34.6
Mature[1]		GM	1−$\frac{3}{32}$	4.38	104.72	50.71	32.32	22	10	12	12	A −	B	19.0	11.04	1.101	.931	5.4	81.8	78.8	34.2
30	Rowden Ser. II	GM sp.	$\frac{31}{32}$	10.08	89.12	—	31.28	162	96	92	46	D	D	14.5	12.02	1.095	.938	3.65	49.5	66.00	35.6
Mature		SM	1	3.73	98.00	46.54	29.02	16	8	11	11	A −	B +	18.1	11.46	1.066	.899	5.22	81.0	82.67	36.2
35	Delfos (Missdel)4 Ser. I	GM sp.	1−$\frac{3}{32}$	7.15	96.20	49.09	33.32	130	66	156	132	D +	D	15.4	12.06	1.289	1.083	3.28	57.2	65.67	42.1
Mature		GM	1−$\frac{1}{16}$	3.84	106.32	54.86	36.86	18	8	44	26	B +	B	17.9	12.60	1.276	1.122	4.12	73.8	71.67	40.8
30	Delfos (Missdel)4 Ser. II	SM sp.	1	11.77	87.68	—	30.88	264	160	292	228	BG[3]	BG	13.5	12.94	1.236	1.027	2.72	48.4	64.33	40.6
Mature		GM sp.	1−$\frac{3}{32}$	3.85	100.24	50.43	34.42	15	5	42	22	B +	B +	17.2	12.90	1.264	1.056	4.12	73.2	67.75	40.0

[1] Open-boll or naturally matured cotton.
[2] Number of seed-coat fragments or neps per 50 yards of yarn.
[3] Below grade of established standards for yarn appearance.

elongation of tire cord and other fiber and spinning properties of the samples spun are included in Table I. It will be observed that, in general, the strength of the yarn was greater in the naturally matured or open-boll samples than in the 30- and 35-day-old fibers from bolls produced from flowers tagged at the same time. However, the 50s yarn in Rowden, Series II, was stronger from the 30-day-old sample than that from the mature cotton of the same tagging, or from the 35-day-old sample of the earlier tagging. The tire cord made from mature cottons was appreciably stronger than that made from the samples picked at 30 and 35 days.

The yarn-appearance grade was better and the number of neps and seed-coat fragments in the yarn decreased as the fibers became more mature. There was an unusually large number of seed-coat fragments in the very young samples. The young seeds broke up in the gin and the seed coats shed freely, leaving numerous particles of epidermis attached to the fibers. It might be said that the improvement in yarn appearance, because of a reduction in seed-coat fragments and neps, was greater than the increase in strength as the cell walls increased in thickness. The percentage of waste and the ease of handling in the various spinning processes were also more favorable for the mature cottons.

Cottons with relatively high percentages of thin-walled fibers may also present problems in appearance, for they become highly colored in storage.[4] The color of cotton fiber collected at different stages of biological development varies with the age of the cotton when picked, even if it is removed from the bolls immediately and dried at room temperature. The color varies from a light-yellow tinge at 40 days to a deep buff or light brown at 20 to 23 days after bloom. It appears that the pigmentation is not due to stain from foreign sources but rather to the chemical reactions taking place in the immature fibers. Bleaching may remove the color, but some loss of strength may be sustained in the process.

Discussion

The results presented here on the strength and cell-wall structure of cotton fibers at progressive stages of development are in agreement with those described by Berkley [6], except that the tensile strengths increase more gradually after 35 days in certain of the series than those previously reported.

[4] Due to the cost of reproduction, an illustration of the color in these immature cottons has been omitted.

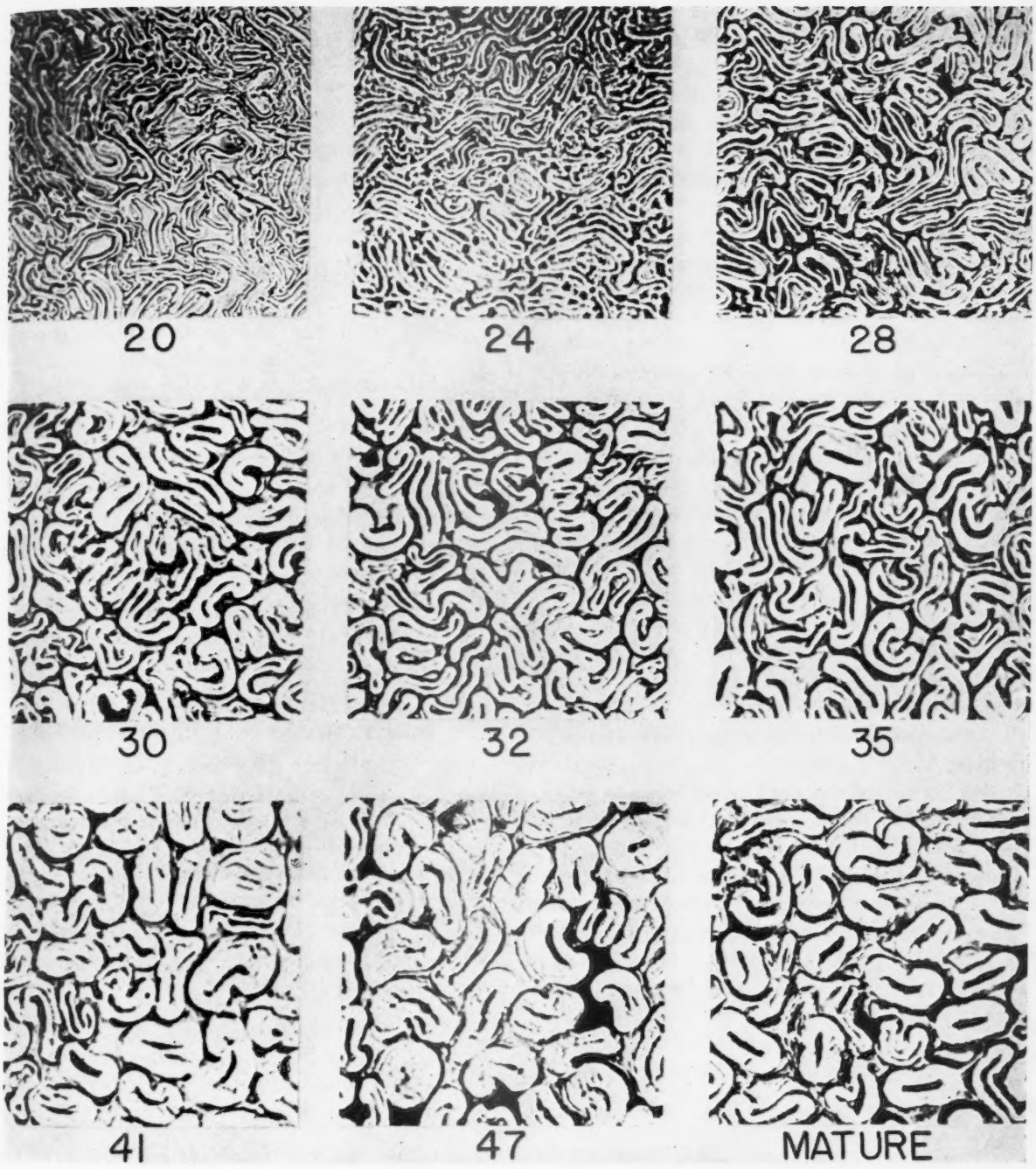

FIG. 3. *Cross sections representing fiber at different ages. The numeral below each figure indicates the age of the fiber in days after bloom.*[5]

The tensile strength, as shown by the improved Chandler bundle method, is dependent to a large degree upon the amount of cellulose per unit area of the cross section of the bundle, other things being equal. More of the thin-walled than of the thick-walled fibers can be packed into the bundles or test specimens, thus making up in large part for the difference in the amount of cellulose per fiber. In the early stages of growth (30 days old or younger), the primary wall apparently constitutes a sufficiently

[5] The cross sections and the photomicrographs were prepared by T. W. L. Bailey, Jr.

large percentage of the fiber to prevent packing enough of the fibers into the bundle to make up an approximately equal amount of cellulose of comparable structure. At the later stages of growth, the increase in the strength observed as the thickness of the cell walls becomes pronounced is approximately equal to that which might be expected from changes in the cellulose orientation as indicated by the x-ray angles. Federov [14], in an experiment similar to that described here, found that cotton collected before the bolls opened gave a stronger yarn than mature or open-boll cotton of the same planting. He states: "The findings show that the worst grade of cotton fiber gave the best and strongest yarn." Rytikoff [21] makes the statement, "Cotton is suitable for commercial use at 40 days after bloom," whereas Sakostschikoff, *et al.* [22] say, "Cotton is usable at 50 days."

These data show also that as far as yarn strength is concerned the cotton at 30 days after bloom is usable; but it is wasty and difficult to process and, because of its color and roughness, might be unsuitable for or impractical to finish for many purposes. However, for uses in which yarn and fabric appearance is not a limiting factor, cottons containing relatively high percentages of thin-walled fibers, such as those obtained by sledding frostbitten plants, may make yarn of acceptable strength. The skein strengths were, for the most part, those to be expected from the fiber properties of length, strength, and fineness, as outlined by Barker and Berkley [5].

These data indicate that a financial loss may be sustained, both by a lower yield and a poorer quality of fiber, if premature defoliation or snapping occurs, or if reasonable precautions are not taken to lessen plant injury by insects or disease that may be conducive to a high percentage of thin-walled fibers.*

Literature Cited

1. Anonymous, Neppiness in Cotton. *Empire Cotton Growing Review* **5**, 97–9, illus. (1928).
2. Anderson, Donald B., and Kerr, Thomas, Growth and Structure of Cotton Fiber. *Ind. Eng. Chem.* **30**, 48–54, illus. (1938).
3. Bailey, M. A., The Causes of Nep in Cotton and the Possibilities of Its Prevention, with Special Reference to the Sudan. Empire Cotton Growing Corporation, Conference on Cotton Growing Problems, Report and Summary Proc. 17–39, London, 1930. (Discussion by Hutchinson.)
4. Balls, W. L., "The Development and Properties of Raw Cotton," London, Macmillan Co., 1915. 221 pp., illus.
5. Barker, H. D., and Berkley, E. E., Fiber and Spinning Properties of Cotton with Special Reference to Varietal and Environmental Effects (manuscript).
6. Berkley, Earl E., Cellulose Orientation, Strength, and Cell-Wall Development of Cotton Fibers. TEXTILE RESEARCH **9**, 355–73, illus. (1939).
7. Berkley, Earl E., Shrinkage and Cell-Wall Structure of Cotton Fibers. *Am. J. Bot.* **29**, 416–23, illus. (1942).
8. Berkley, E. E., and Woodyard, O. C., Structure and Strength of Cotton Fibers: I, X-Ray Method (manuscript).
9. Berkley, E. E., and Kerr, T., Structure and Physical Properties of Undried Cotton Fibers and Changes Occurring upon Dehydration (manuscript).
10. Bowman, F. H., "Structure of the Cotton Fiber," 2nd Ed., Manchester, Eng., Palmer and Howe, 1882. 211 pp., illus.
11. Clegg, G. G., and Harland, S. C., Neps in Cotton Fabrics and Their Resistance to Dyeing and Printing. Brit. Cotton Indus. Res. Assoc., *Shirley Inst. Mem.* **2**, 97–104, illus. (1923).
12. Clegg, G. G., Immaturity of Cotton. Empire Cotton Growing Corp., Conference on Cotton Growing Problems, Report and Summary Proc. 13–17, London, 1930.
13. Clegg, G. G., The Stapling of Cottons. Laboratory Methods in Use at the Shirley Institute, 1931. Brit. Cotton Indus. Res. Assoc., *Shirley Inst. Mem.* **11**, 1–20, illus. (1932).
14. Federov, W., Was Ist Nicht Gereifte Baumwolle und Ist sie für die Textilindustrie Verwendbar. *Vist. Prikl. Bot. (Ztschr. f. Agncw. Bot.)* **3-4**, 57–71 (1930). (In Russian; German summary; English translation available with title: Cotton Paradox, the Spinning Quality of Immature Fibre.)
15. Gulati, A. N., and Ahmad, N., Fibre-Maturity in Relation to Fibre and Yarn Characteristics of Indian Cottons. Indian Cent. Cotton Com., Bom-

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bay Technol. Lab., Technol. Bull., Ser. B 20, 1935. 31 pp.

16. Harrison, George J., Cotton Fiber Imperfections and Their Probable Relation to Yarn Quality. TEXTILE RESEARCH JOURNAL **15**, 247–56, illus. (1945).

17. Pearson, Norma L., Neps and Similar Imperfections in Cotton. U. S. Dept. Agr. Technical Bull. 396, 1933. 18 pp., illus.

18. Pearson, Norma L., Naps, Neps, Motes, and Seed-Coat Fragments. U. S. Dept. Agr. Processed Report, 1937. 7 pp., illus.

19. Pearson, Norma L., Neps in Cotton Yarns as Related to Variety, Location, and Season of Growth. U. S. Dept. Agr. Tech. Bull. 878, 1944. 18 pp., illus.

20. Roehrich, O., Fiber Particles: Part II. Their Production, Deformation, and Degradation. Contribution to the Study of the Degree of Ripening of Cotton. *Faraday Soc. Trans.* **29**, 218–28, illus. (1933). (Discussion by G. G. Clegg.)

21. Rytikoff, M. G., Methods of Collecting Samples and Characteristics of Materials for the Studies of the CCTL NIHI. *Tashkent. Nauch. Issled. Inst. po Khlopkov. Trudy.* [Proc. of the All-Union Sci. Res. Inst. of Cotton Cult. and Indus.] **50**, 7–14 (1931). (English summary.)

22. Sakostschikoff, A. P., Korgenioffsky, G. A., and Rytikoff, M. G., Microscopical Research of the Cotton Fibre of Various Degrees of Ripeness. *Tashkent. Nauch. Issled. Inst. po Khlopkov. Trudy.* [Proc. of the All-Union Sci. Res. Inst. of Cotton Cult. and Indus.] **50**, 15–43, illus. (1931). (In Russian; English summary and English translation.)

23. Watt, Sir George, "The Wild and Cultivated Cotton Plants of the World," London, Longmans, Green & Co., 1907. 406 pp.

Back Issues of "Textile Research" Are Needed

NUMEROUS requests for back issues of *Textile Research*, predecessor of TEXTILE RESEARCH JOURNAL, are being received. The supply, particularly of the earlier numbers, is low and in many instances completely exhausted. If readers of the JOURNAL know of any available copies of issues previous to November, 1941, please notify Textile Research Institute, Inc., 10 East 40th Street, New York 16, New York.

A Fiber Blender

Ruby E. Stewart [1]

A Contribution of the Research Division, Chicopee Manufacturing Corporation

ONE of the most important problems in fiber laboratory procedure is the preparation of a homogeneous sample from which sub-samples may be drawn for various fiber tests. The old method of drawing out small pinches of cotton into a ribbon-like strand to form a hand sliver is both tedious and slow. There is, therefore, a decided need for a laboratory device which will easily and quickly prepare a homogeneous sliver. Such a device, to be satisfactory, must open and mix the cotton with no fiber breakage or loss, and should also do a certain amount of cleaning.

The "Fiber Blender" used by Chicopee at the Texas Technological College was patterned after the original device made by Dr. K. L. Hertel,[2] and was constructed by John Frydryk.[3] The instrument shown in the photograph (Figure 1) consists primarily of two wooden rolls covered with stripper wire which are hand-driven through suitable gearing. The rolls are covered in such a way that the wire points in opposite directions on the two rolls, which arrangement gives teeth pointing in the same direction in the region where the teeth intermesh and the action on the fiber mass actually takes place. The depth of mesh is roughly to the "knee" of the wire, or about 3/8 inch, but this is adjustable, so that with fibers other than cotton somewhat different action may be obtained if desired. The rolls are driven from independent hand cranks through simple gearing, the gearing being provided merely to offset the crankshafts so that the two cranks do not interfere in use. The dimensions of the device are largely arbitrary, but the present size is very satisfactory in actual practice.

In use on cotton, about 5 grams of fiber are distributed more or less evenly around one of the rolls. Thereafter the rolls may be manipulated in a variety of ways to open, clean, mix, and collect the fibers. Rotating the rolls together, by turning one crank and allowing the other roll to follow at its own speed, implants the fibers firmly into the teeth of the wire so that they may subsequently be combed out. Then by holding this roll either fixed or to a slow rotation the other roll may be turned rapidly so that it combs out the fibers, providing a complete opening action and allowing most of the dirt and trash to drop out. During this operation the cotton is transferred from one roll to the other, and then by reversing the procedure it may be transferred back again. By repeating this process half a dozen times, raw cotton may be thoroughly opened and mixed, and cleaned to a relatively complete extent. Doffing of the cotton may be accomplished either by manipulation of the rollers or preferably by a small hand board covered with stripper wire similar to that used on the rolls. This latter operation must be carefully done in order to get a light and fluffy mass of cotton on the hand doffer from which small samples can be abstracted as desired for the various fiber tests.

In order to determine whether or not any fibers were broken in the device, Fibrograph tests were made on a fine-, a medium-, and a coarse-fibered

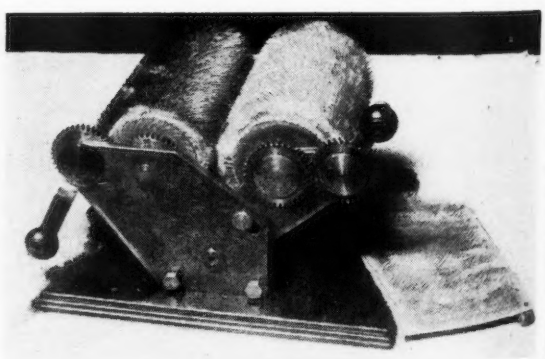

FIG. 1. *Photograph of "Fiber Blender" used by Chicopee Manufacturing Corporation at Texas Technological College.*

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[2] Dr. K. L. Hertel, Head, Physics Department, University of Tennessee, Knoxville, Tennessee.

[3] John Frydryk, Mechanician, Research Division, Chicopee Manufacturing Corporation, Chicopee Falls, Massachusetts.

TABLE I. FIBROGRAPH DATA ON RAW STOCK AND CLEANED COTTON

Sample identification		Length at upper-half mean (in.)						Mean length (in.)						Uniformity ratio
		1	2	3	4	5	Average	1	2	3	4	5	Average	
F*	Raw stock	1.05	0.99	1.02	0.99	1.05	1.02	0.76	0.70	0.73	0.71	0.77	0.73	72
	Cleaned	1.04	0.96	1.01	0.98	1.01	1.00	0.75	0.70	0.70	0.70	0.74	0.72	72
M	Raw stock	1.06	1.03	1.08	1.02	1.06	1.05	0.78	0.73	0.83	0.77	0.83	0.79	75
	Cleaned	1.07	1.03	1.11	1.02	1.10	1.07	0.78	0.74	0.85	0.75	0.80	0.78	73
C	Raw stock	0.84	0.82	0.83	0.83	0.83	0.84	0.72	0.70	0.69	0.70	0.71	0.70	84
	Cleaned	0.81	0.83	0.85	0.82	0.85	0.83	0.67	0.67	0.71	0.68	0.70	0.69	83

*F = fine; M = medium; C = coarse.

cotton before and after they were cleaned. The results, as shown in Table I, give conclusive evidence that the fibers are not damaged. The upper-half mean of the fine cotton ranged from 0.99 to 1.05 inches before the cotton had undergone the operation, and 0.96 to 1.04 inches after, with an average of 1.02 inches before and 1 inch after. The medium cotton showed opposite results, as it ranged from 1.02 to 1.06 inches before and 1.02 to 1.11 inches after, with an average of 1.05 before and 1.07 inches after opening. The coarse cotton showed very little difference, averaging 0.84 inch before and 0.83 inch after. In all cases there was considerable overlapping of the lengths in both the raw stock and the cleaned cotton. Also, there was very little difference in the mean lengths and the uniformity ratios.

This device has also proved to be very successful for preparing samples for the air permeameter, an experimental instrument for determining fiber fineness. Because of the air flow principle of the air permeameter, the samples must be well opened and partially cleaned to obtain a uniform density, and the Fiber Blender satisfies these requirements admirably.

C.P.A. Releasing Skilled Employees

THE Civilian Production Administration (formerly W.P.B.) has announced the release of approximately 200 skilled employees, men and women, in the New York State and Northern New Jersey Region. Also the New York Region has 65 men in the Armed Services ready for release.

The majority of these individuals came to W.P.B. direct from business and industry and C.P.A. is endeavoring to assist them in finding suitable openings. Included in the industrial skills listed are chemicals, cost control, electrical engineering, engineering, and market research, and the list mentions physicists and statisticians.

Inquiries should be made to Arthur B. Sherman, Manager, Jobs in Industry Unit, Civilian Production Administration, 43d Floor, Empire State Building, New York 1, New York; telephone, MUrray Hill 3-6800, Extension 275.

ABSTRACTS

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Reprints of the original articles abstracted in TEXTILE RESEARCH JOURNAL *are often available from the publishers. Otherwise, it may be possible to secure copies of the periodicals. A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications was given on page 22 of the January, 1945, issue. Orders should be sent direct to the publishers.*

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Subscriptions to reprints of the Abstracts section for Volume 16, 1946, are now available to subscribers to the JOURNAL. *These are printed on one side of the sheet for clipping and filing in a card index system. The charge for this service is $3.00.*

ANALYSIS: TESTING: LABORATORY METHODS

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Analysis of Plastics

Chemical analysis and structure determination of plastics. W. Esch and R. Nitsche. *Wiss. Abhandl. deut. Materialprüfungsanstalt* **2**, No. 1, 22–9 (1941); *Chem. Zentr.*, **1941, II**, 1687 (through *Chem. Abstr.* **39**, 4518⁷, Oct. 10, 1945).

A preliminary qualitative test consists in heating, in a test tube, the dry sample in an oil bath. Thermosetting resins remain hard if already set, and harden after intermediate softening or melting if in the A-stage. Thermoplastics soften or melt at different temperatures and retain their characteristic solubility properties after cooling providing that decomposition has not taken place. Hardened thermosettings are insoluble in common organic solvents. Further information is obtained by thermal decomposition. Phenolics and urea resins are readily recognized by the characteristic odor of the decomposition products. In the case of thermoplastics, the decomposition products are separated and analyzed. Many polymers and copolymers, such as polystyrenes, polyacrylates, and polymethacrylates, are depolymerized and can be recognized by identification of the polymer. Polychlorides from HCl, polyvinyl acetate, and cellulose acetates yield AcOH, benzyl cellulose gives gaseous decomposition products characterized by the characteristic odor of BzOH, cellulose nitrate evolves NO_2, and casein products develop the odor of burning hair. The quantitative analysis of phenolics is described in detail. Hexamethylenetetramine (*I*) is determined by extraction with water at 50°. Accelerators are determined by Kjeldahl N determination according to or by liberation and determination of CH_2O or NH_3. After determination of *I* and accelerators, the sample is dried at 70°, and extracted in a Gräfe apparatus with acetone. The residue is dried, and distilled dry, and the distillate is analyzed for phenols and cresols. The residue remaining after distillation is examined under the microscope for fibrous fillers. A portion of the sample is ashed for the determination of inorganic matter. Another portion is heated with soda lime at 250° for about 4 hrs., and extracted with water. If the extract contains phenols, the possibility that the sample contains ground phenolic scrap is indicated. The quantitative analysis of urea resins is performed analogously to the analysis of phenolics. The determination of organic fillers in thermosettings and the estimation of the number of layers in laminates is possible by a study of the effect of organic bases, phenols, and particularly naphthols. A short-time treatment with molten naphthol indicates the structure of the product. If a sample is immersed in molten naphthol at 160–180° for 24 hrs., then dipped in boiling alcohol-benzene (1 : 3), extracted with ether, and finally dried in air, the resulting loss in weight indicates the amount of resin. In the quantitative analysis of thermoplastics, the plasticizer is separated by extraction with ether; polymer and filler are separated by suitable solvents; and both polymer and filler fractions are further analyzed.

Water-Repellency

Properties and testing of woolen articles containing staple rayon which have been treated for water-resistance. J. Stadler and B. Hartmark. *Melliand Textilber.* **24**, 311–13 (1943) (through *Chem. Abstr.* **39**, 4490⁴, Oct. 10, 1945).

The usual tests of the physical properties of these materials may give misleading indications of their quality and behavior in practice. Comparisons between articles made from staple rayon-wool mixtures before and after impregnation with Kaurit KF, Ramasit KGT concentrate, or Persistol NO showed that on wetting and hydroextraction most H_2O is obtained from the impregnated cloth. The rate of drying is the same for

both when the H_2O is uniformly distributed; when it is not, the treated cloth dries the slower. On treatment by the Bundesmann "rain test," less H_2O is absorbed by the treated cloth; on then shaking the articles and allowing them to dry, H_2O is lost much the more rapidly from the untreated cloth. The more rapid removal of moisture from a wet untreated cloth produces a cooling effect, which aids the skin respiration of the wearer; from this viewpoint therefore, impregnation, which closes the pores of the cloth, is a disadvantage.

CHEMICAL AND PHYSICAL RESEARCH

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Alginic Acid

Structure of alginic acid. W. T. Astbury. *Nature* **155**, 667–8 (June 2, 1945) (through *Bull. Inst. Paper Chem.* **16**, 4 (Sept. 1945)).

The author discusses the structure of alginic acid based on the x-ray diagram of alginic acid fibers. The evidence from the x-ray analysis is in favor of the pyranose formula; however, the period along the fiber axis amounts to 8.7 Å. The author speculates on the reasons for the difference in the fiber period between alginic acid and cellulose with a period of 10.3 Å. There is no reason, from the properties of the fibers, to think that the chain of β-*d*-mannuronic acid residues is not stereochemically fully extended; therefore, presumably, the cellulose and alginic acid configurations are alternatives derivable from common postulates. Two skeleton models of the chain configuration of both substances are given.

Cross-Linked Cellulose Fibers

New synthetic textile fibers and possibilities for improving cellulosic fibers. Ehrhardt Franz. *Z. Ver. deut. Ing.* **85**, 604 (1941); *Chem. Zentr.* **1941, II**, 1808 (through *Chem. Abstr.* **39**, 4228[6] (Sept. 20, 1945)).

A discussion of protein fibers (Thiozell) and improvement of cellulosic fibers. Cross-linkages are introduced by the use of HCHO, higher dialdehydes, or disulfides to compensate for the depolymerization which is a prerequisite for solution and spinning. Improvements in the resistance of the sensitive nucleus to H_2O and alkalies have been attempted by "wrapping" the fiber (i.e., by covering the surface with a resistant layer). The condensation products in use improve the alkali solubility, and decrease the swelling properties and the tendency to cleavage in the longitudinal direction. The treatments must be modified according to the nature of the fiber. Since the artificial fiber already possesses a parallel arrangement, it is suitable, after a new treatment (not indicated), for use as a yarn (binding twine).

Fiber Density

Cellulose fibers: The determination of the density of cellulose in different media. K. Lauer and U. Westermann. *Kolloid-Z.* **107**, 89–93 (May 1944) (through *Kodak Mo. Abstr. Bull.* **31**, 82 (Mar. 1945)).

The densities of cotton and viscose fibers were determined in water, in methyl, ethyl, and *n*-propyl alcohols, acetone, acetic acid, benzene, pyridine, and petroleum ether, and the results compared with the corresponding heat of sorption values. The densities did not vary regularly with the heat values. It is pointed out that the density of cellulose has a physical significance only when referred to a given medium.

Fiber Structure

The structure of certain muscle fibrils as revealed by the use of electron stains. C. E. Hall, M. A. Jakus, and F. O. Schmitt. *J. Applied Phys.* **16**, 459–65 (Aug. 1945).

Fibrils from certain molluscan muscles, in particular the adductor muscles of the clam *Venus mercenaria*, were examined with the electron microscope and found to possess periodic variations in structure. In order to make these structural variations visible, it was necessary to treat the fibrils with reagents of high electron scattering power (electron stains). Phosphotungstic acid was found to be particularly suitable. This stain combines with specific regions in the fibrils, forming a remarkably regular geometrical pattern of which the most prominent feature is a regular cross striation, representing a fiber-axis spacing of about 145 Å. Within each stained band, the stain is more highly concentrated in spots spaced about 193 Å. from center to center across the band. A line drawn through any such spot parallel to the fiber axis passes through other similar spots, spaced 5 cross bands apart, making the length of the fiber-axis period precisely 5 times the fiber-axis spacing. X-ray diffraction data obtained by Bear from the intact muscles are compared with the electron microscope observations. The small angle diffractions are in close agreement with those which would be expected from the observed structure except for the magnitude of the lateral spacing. Electron microscope values for this spacing are significantly smaller than the 325 Å. indicated by the x-ray data, probably as a result of lateral shrinkage in the vacuum-dried electron microscope specimens. No significant difference in axis spacing has been observed in fibrils isolated from muscles fixed with alcohol in contracted and extended states.

Author

Plastic Materials

Variation of tensile strength and elongation of plastics with temperature. R. T. Schwartz. *Modern Plastics* **25**, 153–5, 194–5 (Sept. 1945).

The tensile strength and elongation of a variety of typical filled and unfilled thermosetting and thermoplastic plastic materials were determined at a temperature of 158°F in a heated room containing the test equipment. The materials tested included as fillers: fine-weave cotton fabrics, coarse-weave cotton fabrics, canvas, cotton duck, paper, and glass. This procedure was followed so that both the test specimens and apparatus would be at the test temperature. Data obtained in a similar manner

for low temperatures down to −38°F in a refrigerated room are also included. In general, it was found that tensile strength decreased and elongation increased with increasing temperature throughout the temperature range investigated. The unfilled thermoplastic materials were very much more affected by temperature than the unfilled or filled thermosetting plastic materials. The variations of tensile strength and elongation with temperature were not linear for any of the materials. The various unfilled thermoplastic materials decreased from 13 to 100% in tensile strength at 158°F and increased from 58 to 177% at −38°F, compared to room temperature. The thermosetting plastic materials, filled and unfilled, decreased from 5 to 38% in tensile strength at 158°F and increased from 5 to 20% at low temperatures of −38° and −67°F, as compared to room temperature. In general, the thermosetting plastic materials exhibited low elongation at room temperature and there was little perceptible change with temperature of elongation at fracture as measured by dividers. The thermoplastic materials having an appreciably higher elongation at room temperature than the thermosetting plastics decreased markedly in elongation with decrease of temperature through the range studied. J.

Phenol Condensations

Indirect phenol-aldehyde condensations. J. B. Niederl and I. W. Ruderman. *J. Am. Chem. Soc.* **67**, 1176–7 (July 1945).

When *p*-alkylated phenols are condensed with *p*-alkylated phenol dialcohols (2 : 6) in glacial acetic acid saturated with HCl, polymers with molecular weights of approximately 1,500 are formed. When *o,p*-alkylated phenols are used a trimer is formed. A. R. Macormac

Rheology

Rheology: the dynamics of real fluids. E. G. Richardson. *Endeavour* **4**, 64–8 (Apr. 1945) (through *Bull. Inst. Paper Chem.* **16**, 29 (Sept. 1945)).

The author describes the basic concepts underlying the dynamics of fluids, with particular reference to the abnormal behavior of non-Newtonian fluids. He explains the following terms: apparent viscosity, yield value, sol, gel, elasticity and bulk elasticity, thixotropy, relaxation time, and emulsions and foams. It is now evident that many of the liquids used in every-day life in both domestic and industrial spheres belong to the non-Newtonian type; the importance of continued studies of their flow properties—the science of rheology—is emphasized.

Extrusion of Vinyl Resins

The extrusion of plasticized polyvinyl chloride compositions. E. L. Midwinter. *Brit. Plastics* **17**, 161–70, 181 (Apr. 1945).

The effects of temperature, machine design, breaker and strainer plates, accurate centering of conductor, haul-off gear, and production rates for the extrusion of plasticized polyvinyl chloride over wire are discussed. Trends toward multi-die extrusion, longitudinal covering, and preheating with high-frequency current and infra-red light are indicated. The extrusion of tubes and solid sections is briefly discussed.

E. F. Evans

Electrophysical Properties

Plastics and elastics. Electrophysical properties—Part II. L. Hartshorn. *Brit. Plastics* **17**, 186–92 (May 1945).

The electrophysical properties of thermosetting and thermoplastic polar materials and non-polar materials are discussed and literature data illustrating these fundamental properties and the principles discussed in Part I are presented. E. F. Evans

Ion Exchange Processes

Ion exchange. An old process finds new uses. Sidney Sussman and Albert B. Mindler. *Chem. Ind.* **56**, 789–95 (May 1945).

A review of the applications of ion exchange agents, both natural and synthetic. These are used for (1) removal of undesirable ionic impurities, (2) addition of specific ions to solutions, (3) recovery of valuable substances, (4) separation or fractionation of electrolytes, (5) contact agents (e.g., catalysts). Limitations are (1) the necessity of regenerating the exchanger, and (2) small ion capacity which does not permit use with concentrated solutions. Ion exchange operating costs and engineering design are briefly discussed. E. D. Klug

Furans and Pyrans from Glucose

The condensation of glucose and beta-diketones. J. K. N. Jones. *J. Chem. Soc.* **1945**, 116–19 (Feb. 1945).

Employing the known condensation of glucose with beta-diketones in the presence of anhydrous zinc chloride to give derivatives of furan, glucose has been condensed with acetyl acetone to yield 2-methyl-5-(*D-arabo*-tetrahydroxybutyl)-3-furyl methyl ketone. These furan derivatives have been found to rearrange readily upon heating with dilute aqueous acids to yield pyran derivatives. Thus the above furan derivative yielded 7,8-*D-erythro*-dihydroxy-2-methyl-1,5,6,7,8,9-hexahydro-1,5-dioxa-3-naphthyl methyl ketone when heated with 50% acetic acid.

E. F. Evans

Elastic Behavior of Rubber

The dependence of damping and dynamic modulus on temperature as a means of evaluating the elastic behavior of raw and vulcanized rubber. The dynamic resistance of soft rubber to cold. H. Roelig. *Rubber Chem. Tech.* **18**, 62–70 (Jan. 1945).

The method of determining the hysteresis loop, from which damping and dynamic modulus are measured, and application of the results to problems of heat build-up in tires; and use of rubber in vibration dampers and significance of relaxation times in questions of structure are discussed. Data are presented on the temperature-dependence of damping and dynamic modulus as affected by type of raw rubber, other components in final mixture, and extent of vulcanization. The most important features to be noted are

the temperature at which there is no damping ("freezing" point), the temperature of maximum damping and the value of the maximum, and the behavior of the damping value at higher temperatures. It is pointed out by way of illustration that for use in tires it is desirable to have damping drop off rapidly with increase in temperature, while rubber for vibration dampers should have a relatively high damping value which changes very little over the range from 5° to 100° C. The effect of frequency of applied stress on damping is discussed briefly, but no data are given. W. E. Davis

Oxidation of Rubber

Distribution of oxygen in oxidized rubbers. R. F. Naylor. *Rubber Chem. Tech.* **18**, 32–40 (Jan. 1945).

The distribution of oxygen among hydroperoxide, hydroxide, carbonyl, carboxyl, and ester groups was studied on the following samples of oxidized rubber: Rubbone-C (most soluble portion of commercial oxidized rubber prepared by mastication in air); nitrite crumb (prepared by adding sodium nitrite to latex before coagulation with acetic acid); and three samples of autoxidized rubber prepared in the presence of boiling phenol. The analytical methods used for determination of oxygen distribution are described, and data are presented on molecular weight (viscosimetric), iodine number, elemental analyses, oxygen distribution, and solubility. In no case does the amount of oxygen determined in various specific groups total the amount calculated from the C, H, N analyses. This is attributed to the fact that oxygen in epoxide and ether groups was not determined for lack of suitable methods. The change in unsaturation calculated on the assumption that all the missing oxygen is in the form of epoxide groups formed by addition of oxygen to double bonds agrees well with the change in iodine number on oxidation in most cases. The data are consistent with the hypothesis that initial formation of rubber peroxides is followed by oxidative fission of double bonds; this reaction apparently proceeds very nearly to completion, as the peroxide contents of all the rubbers are quite low. Carboxyl contents of several per molecule were found in several cases; these are not discussed, but would appear to indicate appreciable oxidation of side-chain methyl groups. The suggestion is made that part of the large proportion of oxygen unaccounted for in nitrite crumb may, together with nitrogen, be involved in some sort of cross-linking, which would account for the peculiar solubility characteristics of this material.

W. E. Davis

Heat Development in Rubber

Damping, heat development, and the length of life of vulcanizates. A. Springer. *Rubber Chem. Tech.* **18**, 71–82 (Jan. 1945).

A discussion of the relationships which should exist among damping, temperature, frequency of stressing, and the thermal characteristics of rubber (heat capacity and conductivity) on a theoretical basis, showing to what extent these relationships are realized in practice. The maximum temperature attained by a specimen undergoing repeated stress is shown to be a linear function of absolute damping and of frequency, as expected; rise in temperature is an exponential function of time, which is also in agreement with theory. Methods of measuring the various quantities involved in the equations are discussed briefly. The destructive action of repeated stressing is attributed to chemical reactions promoted by the increase in temperature, and on this basis the relationship which should exist between length of life and temperature is developed, and shown to agree with experimental results.

W. E. Davis

Reaction of Halogens with Rubber

Reactions of iodine, iodine chloride, and thiocyanogen with the hydrocarbons of natural rubber and synthetic rubber. P. I. Medvedchuk, F. D. Aldoshin, V. P. Marovich, and A. V. Repman. *Rubber Chem. Tech.* **18**, 24–31 (Jan. 1945).

After a brief discussion of earlier work on the reaction of halogens with the hydrocarbons of rubber, balata, and gutta-percha, the preparation of synthetic rubber (polymerization of butadiene with sodium) and the purification of natural rubber hydrocarbon are described. Data on the reaction of these products with iodine are not complete, but in the case of the reactions with iodine chloride and thiocyanogen, data are presented on the rates of the reactions and the methods of isolating the products and their solubilities; reactions to heating and analyses are given. With both iodine chloride and thiocyanogen, the synthetic polymer reacts more slowly than the natural hydrocarbon; in the case of thiocyanogen, halogen is still being used up at an appreciable rate when the amount consumed is equal to the theoretical for complete saturation of the double bonds in the rubber. It is suggested that this may be due to polymerization or other side reactions of the thiocyanogen. In all cases the products isolated at halogen consumptions corresponding to saturation of double bonds have analyses fairly close to those calculated for quantitative addition. It is concluded that the chemical properties of the two polymeric hydrocarbons are in general similar. W. E. Davis

Vibration Characteristics of Rubber

Effect of temperature on the vibration characteristics of natural and synthetic rubbers. J. D. Morron, R. C. Knapp, E. F. Linhorst, and P. Viohl. *Rubber Chem. Tech.* **18**, 83–96 (Jan. 1945).

Methods of determining stress-strain curves, tensile strength, and vibration transmission over a wide range of temperatures are described, and results are given for natural rubber and several synthetics (GR-S, GR-M, GR-I, and Perbunan). These show that the effect of temperature on the functions of vibration insulators is much greater than would be expected on the basis of tests commonly used to determine the effect of low temperatures on elastomers (e.g., the brittle point value). Several points are given particular em-

phasis. One such is the existence of a "barrier point," which is the temperature below which a sample will not warm up because of vibration, no matter how long-continued. It is also pointed out that improvement in vibration insulation can be obtained by means of increased initial deflection; i.e., higher loading. It is worthy of note that the tests show natural rubber to be much superior to any of the synthetics as a vibration insulator at low temperatures. W. E. Davis

Seaweed Rayon

Seaweed rayon. J. B. Speakman. *Nature* **155**, 655–7 (June 2, 1945); cf. *B.I.P.C.* **15**, 153 (through *Bull. Inst. Paper Chem.* **16**, 5 (Sept. 1945)).

The material in this article is similar to that of the previous reference, although it is in a much more concise form. Three graphs are included in the present paper which have not been published before: the adsorption and desorption isotherms of calcium alginate and wool at 25°C, water adsorption as a function of the metal content, and the relationship between optimum metal content and optimum tenacity. 15 references.

Properties of Surfaces

The properties of freshly formed surfaces. Part IV. The influence of chain length and structure on the static and the dynamic surface tension of aqueous-alcoholic solutions. C. C. Addison, *J. Chem. Soc.* **1945**, 98–106 (Feb. 1945).

The vibrating-jet technique already described has been applied to the measurement of both static and dynamic surface tensions of aqueous solutions of alcohols containing 1 to 8 carbon atoms. The static tensions at high concentrations have been used to evaluate the Szyszkowski constants, and the work of adsorption has been deduced from the static tensions at great dilution. Dynamic surface tensions are recorded for aqueous solutions of *n*-amyl, *n*-hexyl, *n*-heptyl, and *n*-octyl alcohols over a range of surface ages, and the migrational velocity has been shown to increase with increasing chain length. Branching of the carbon chain (as in *iso*amyl or *tert.*-hexyl alcohol) or alteration in the position of the hydroxyl group as in *sec*-octyl alcohol) appears to reduce the migrational velocity, and possible reasons for this are discussed. Author

Strength of Bundles of Threads

The statistical theory of the strength of bundles of threads—I. H. E. Daniels. *Proc. Roy. Soc.* **A183**, 405 (June 18, 1945).

A group of parallel threads of equal length, clamped at each end so that all threads extend equally under tension, is called a bundle, and the maximum load which the bundle can support is called its strength. The object of the work is to study the probability distribution of the strength of bundles whose constituent threads are sampled randomly from an infinite population of threads in which the probability distribution of strength is known. The relation between the strength of a bundle and the strengths of its constituent threads is first discussed, and results are given for bundles so large that the proportions of threads of different strengths approach their expectations. The properties of the probability distribution of bundle strength are discussed in detail, attention in the present paper being confined to the case in which all threads have the same load-extension curve up to breaking point. Finally, the asymptotic behavior of the distribution for large numbers of threads is studied, and it is shown that in the commonest cases the distribution tends to assume the normal form. Author

Vulcanization of Buna-S

Vulcanization of Buna-S (GR-S) with organic sulfur compounds. M. C. Throdahl and D. J. Beaver. *Rubber Chem. Tech.* **18**, 110–15 (Jan. 1945).

None of the aliphatic or aromatic sulfides tested were found to have any vulcanizing activity. Buna-S vulcanized with acid, thiocyanic, amine, thiuram, or phenolic sulfides showed better resistance to cut-growth and heat embrittlement than normal vulcanizates containing free sulfur, but heat generation was higher. Information given in the paper includes data on compounding and values of 300% modulus, tensile strength, and elongation for both normal and aged samples.

W. E. Davis

Vinidur and Oppanol

Vinidur and Oppanol in the rayon and staple-fiber industry. Walter Krannich. *Jentgen's Kunstseide u. Zellwolle* **23**, 202–7 (1941); *Chem. Zentr.* **1941**, **II**, 2039; cf. *C.A.* **38**, 1149[5] (through *Chem. Abstr.* **39**, 4490[3], Oct. 10, 1945).

Examples of application with illustrations.

Action of Alkalies on Wool

The action of alkalies on wool. I. The subdivision of the combined cystine into two fractions differing in their rate and mode of reaction with alkalies. W. R. Cuthbertson and H. Phillips. *Biochem. J.* **39**, 7–17 (1945) (through *Bull. Inst. Paper Chem.* **16**, 43–4 (Sept. 1945)).

Only about one-half of the total combined cystine of wool is converted by alkaline solutions into combined lanthionine. The rate of conversion increases with increase of pH and rise of temperature. When the remaining half of the combined cystine of wool is decomposed by alkaline solutions, each molecule gives rise to 2 molecules of combined α-aminoacrylic acid. The rate of decomposition is slow at pH 8, but increases as the pH increases and the temperature rises. Nearly all the combined cystine of wool is converted into combined lanthionine when wool is treated with solutions of potassium cyanide. An examination of the hydrolyzates of alkali-treated wools has failed to provide evidence of the formation of —SNH— and —CH=N— cross-linkages, and intact alkali-treated wools do not contain free aldehydic groups which will combine with ρ-bromophenylhydrazine. It has been confirmed that the total sulfur in wool, undamaged by light

or detergent solutions, can be accounted for as cystine and methionine sulfur. 40 references.

Action of Alkalies on Wool

The action of alkalies on wool. II. The identity of the lanthionine-forming and bisulfite-reactive fractions of the combined cystine of wool. H. Lindley and H. Phillips. *Biochem. J.* **39**, 17–23 (1945) (through *Bull. Inst. Paper Chem.* **16**, 44 (Sept. 1945)).

The combined cystine of wool has been divided into two equal fractions called $(A + B)$ and $(C + D)$ which differ in their mode of reaction with weak alkalies and sodium bisulfite. Fraction $(A + B)$ gives combined lanthionine when the wool is treated with alkalies, and thiol and *s*-cysteine-sulfonate groups when the wool is treated with sodium bisulfite. Fraction $(C + D)$ is converted into α-aminoacrylic acid by alkalies and also by warm solutions of sodium bisulfite, but does not react with sodium bisulfite at room temperature. Each fraction of the combined cystine has been divided into two subfractions. Subfraction *A* yields lanthionine more rapidly and at lower alkalinities than does subfraction *B*. Subfraction *A* yields water-labile thiol and *s*-cysteine-sulfonate groups, whereas the thiol and the *s*-cysteine-sulfonate groups derived from subfraction *B* are water-stable. Subfraction *D* is converted to combined α-aminoacrylic acid by alkalies and sodium bisulfite more readily than subfraction *C*. No significant difference has been found between the reactivities toward weak alkalies of unstretched wool fibers and those which had been stretched 30%. 16 references.

Sorption by Keratin and Wool

Sorption of vapors by keratin and wool. G. King. *Trans. Faraday Soc.* **41**, 325–32 (June 1945); cf. *B.I.P.C.* **10**, 359 (through *Bull. Inst. Paper Chem.* **16**, 44 (Sept. 1945)).

The absorption and desorption rates for water, methyl alcohol, and ethyl alcohol by wool and horn keratin have been investigated for those cases in which diffusion is the rate-controlling process. The results confirm the conception of a diffusion coefficient which increases with concentration, and show that this leads to the building up of a steep front, which advances through the medium as the absorption proceeds. This does not affect the parabolic form of absorption for semi-infinite media, but leads to an approximately linear rate in the case of finite media. 8 curves.

Textile Wetting Agents

Wetting agents in textile processing. IX. Na lauro-*p*-toluide-3-sulfonate. E. D. Daruwala, B. D. Tilak, and K. Verkataraman. *J. Indian Chem. Soc., Ind. News Ed.* **7**, No. 1, 24–8 (1944); cf. *C.A.* **35**, 3099[5] (through *Chem. Abstr.* **39**, 2662[8] (June 20, 1945)).

The –CONH– group of 4-$CH_3C_6H_3$-(3-SO_3Na)$NHCOC_{11}H_{23}$ (**I**) is partly responsible for the good detergent properties of the compound; it interrupts the hydrophobic part of the molecule and helps make it substantive toward cotton. Affinity for the textile fiber permits economic application from a dilute solution. $C_{11}H_{23}COCl$ (1 mole) was gradually added to a stirred solution of 1 mole of 4-$CH_3C_6H_3NH_2$(3-SO_3H) in 2 moles of 10% NaOH at 5–10°, stirred 3 hrs. at 10°, and gave a cream-colored paste (**II**) which was evaporated to a cream-colored powder (**III**). **III** extracted with EtOAc gave pure **I**. Solutions of **I**, **II**, and **III** were stable and gave clear solutions with 10% Na_2CO_3, 5% H_2SO_4, and 1% $CaCl_2$. Igepon T and Gardinol WA were purified by extraction with EtOAc; Nekal BX was purified by the use of dioxane; Igepal C and Triton NE were purified by the removal of water. Aerosol OT, nearly 100% pure pellets, was not further purified. **I**, **II**, **III**, and the commercial and purified commercial wetting agents were compared in their properties by the Herbig number (*C.A.* **33**, 392[5]), Draves test (*C.A.* **25**, 5296), Ca-soap-dispersion power (*C.A.* **33**, 871[8]), and Congg Rubine number (*C.A.* **31**, 1626[8]). **I** except for Aerosol OT at 0.25% concentration, gave the lowest Herbig number. **I** and purified Igepon T, Igepal C, and Triton NE were about equally resistant to hard water; Gardinol WA, Nekal BX, and Aerosol OT were next in order. **I** showed superior protective colloidal action by the Congo Rubine number, and was found to have better all-around properties. Technical production covered by Indian patent 27,443 and British 545,496 (*C.A.* **37**, 1533[4]) will shortly be undertaken.

Wool Shrinkage

Reactivity of the sulfur linkage in wool. W. J. B. Neish and J. B. Speakman. *Nature* **155**, 45–6 (Jan. 13, 1945).

Further evidence is presented that disulfide-bond breakdown is the essential cause of unshrinkability in treated wool fabrics. Flannel which had been treated with reagents which break disulfide bonds, such as chlorine or sulfuryl chloride, shrunk only 0–4% upon laundering, but when the disulfide bonds were stabilized by treating the flannel with cold dilute sodium hydroxide for 24 hrs. the shrinkage after chlorine or sulfuryl chloride treatment was 13–18%. The results also indicate that operations in which wool is subjected to the action of dilute alkalies, such as scouring, must be closely controlled if subsequent treatments to obtain unshrinkability are to be effective. H. W. Theller

Wool Structure and Properties

Wool—its physiology, structure, electrostatic phenomena and chemistry. Justin-Mueller. *Teintex* **8**, 3–10 (1943); *Chem. Zentr.* 1944, **I**, 908 (through *Chem. Abstr.* **39**, 3163[7] (July 20, 1945)).

The formation of scales on wool fiber, the swelling of wool by concentrated NH_3 and NaOH, recent studies on the fine structure of wool, its chemical nature, and importance of S content are discussed. Aqueous fat emulsions and ionization of the atmosphere are effective in eliminating positive electrostatic charges in wool. Wool is not an amino acid; it produces these acids only on extensive decomposition. The absorption of acids and alkalies is not chemical in nature; it is reversible, and does not

affect the chemical structure of the woolen fiber. The following chemical reactions of wool are discussed: effect of strong, hot acids and alkalies, the biuret reaction, hydrolysis in an autoclave at 140° in the presence of HCl or NaOH and detection of decomposition products by their colored Cu and Fe salts.

BLEACHING: DYEING FINISHING

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Acetate Dyeing

Dyeing of acetate rayon. Richard Hünlich. *Appretur-Ztg.* **33**, 99–101 (1941); *Chem. Zentr.* **1941, II**, 2023 (through *Chem. Abstr.* **39**, 4489[7], Oct. 10, 1945).

A discussion of the dyeing of acetate rayon and of union fabrics containing acetate rayon and wool or cotton with Celliton, Celliton Fast, and Cellitazol dyes, and with indanthrene dyes in a faintly alkaline bath.

Union Dyeing

The dyeing of union fabrics. T. Valette. *Teintex* **6**, 156–9 (1941); *Chem. Zentr.* **1941, II**, 2023 (through *Chem. Abstr.* **39**, 4489[5], Oct. 10, 1945).

In the dyeing of mixtures of acetate rayon with viscose rayon, cotton, and silk by means of direct S and vat dyes, excessively high alkalinity of the baths must be avoided to prevent saponification of the acetate rayon. Na phenolate can be used in place of NaOH in the vat bath. Sizes and their removal are described. Various gums and alginates are preferable to the difficultly removable paraffins, etc. Mixtures of wool and silk, the proper selection of dye and temperature regulation, the dyeing of a wool-silk mixture with acid dyes, Alkali Blue, nigrosine, induline, cold-dyeing dyes, etc., black dyeing with white silk effects, the brightening of soiled silk with NH_4 oxalate, fabric with cotton warp and viscose weft, and dyeing with alkaline Igepon baths containing light-fast dyes that give the same color tone to viscose and cotton are discussed.

Antiseptic Agents

The antiseptic properties of surface-active agents. Lawrence H. Flett. *Oil and Soap* **22**, 245–9 (Oct. 1945).

Data are presented which show that anionic detergents such as Naccol NR are general antiseptics which are effective against bacteria, fungi, yeast, and insects. These detergents can be used in neutral and acid solutions to give a much stronger antiseptic action than is possible with soap solutions. They are not powerful antiseptics in extremely dilute solutions, but are effective at concentrations generally used for washing. Moreover, they are non-volatile and non-toxic. E. Dermaner

Warp Sizing

Staple fiber converting practices in the spinning and weaving industry. E. O. Hesse. *Klepzigs Textil-Z.* **44**, 828–9 (1941); *Chem. Zentr.* **1941, II**, 2039 (through *Chem. Abstr.* **39**, 4490[2], Oct. 10, 1945).

Too little size carried on the finishing roll results in too soft warp threads, which can hardly be removed from the loom. With the addition of glycerol to starch size, the moisture relations of the operation or weaving room must be considered; well-finished warp threads can absorb so much moisture that they become flabby and give rise to knot formation during weaving. The best sized warp threads are now obtained with chemical sizes which are superior to the usual starch size.

Water Softening

Threshold treatment of water. J. C. Skerrett. *Can. Chem. and Proc. Ind.* **29**, 226–9 (Apr. 1945).

Scale and corrosion are prevented by the threshold treatment of water. Precipitation of calcium carbonate is prevented by addition to the water of 2 p.p.m. metaphosphate, which is not nearly the equivalent of the amount of calcium present. This is brought about by the adsorption of an extremely thin layer of metaphosphate on the minute calcium carbonate particles as they start to form. The film keeps the particles from growing larger and adhering to the metal surfaces. The metaphosphate is also adsorbed by the metal and the surfaces are protected until the film layer formed is destroyed. E. Dermaner

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Competition Between Fibers

Post-war question: Cotton versus synthetic fibers or cotton and synthetic fibers. John Leahy. *Textile Bulletin* **68**, 21–2, 44 (Aug. 1, 1945).

Effect of post-war competition from synthetic fibers on cotton is discussed with regard to price relationships, potential increases in production of synthetic fibers, efforts to improve the utility of cotton fiber and cotton products, and the situation in foreign countries. R. B. Evans

Fiber from Desert Plants

Utilization of fiber of desert plants. C. W. Botkin. *Chemurgic Digest* **4**, 226–9 (July 15, 1945); cf. *B.I.P.C.* **14**, 111–12 (through *Bull. Inst. Paper Chem.* **15**, 452 (Aug. 1945)).

The author gives an additional account of information gained in the utilization of the fibers of nolina and flexible-leaved and rigid-leaved yuccas, stressing particularly the economic angle of harvesting and regrowth. *Glauca yucca*—one of the flexible-leaved species—has been made into a special paper for the Navy by a mill near the East Coast. However, the most obvious uses of the fiber are for twine, rope, and burlap.

Fiber Processing

More mixing and less handling of fibers. Anon. *Am. Wool and Cotton Reptr.* **59**, 7, 8, 25 (Aug. 23, 1945).

An article stressing the importance of blending during the picking operation, low beater speeds, and conditioning before making up of blends

in the running of synthetic fibers. A roller-top card is preferred over a flat card. Relatively light slivers and single roving in spinning are recommended. H. J. Burnham

DeWitt Smith on Fibers

Textile fibers. An engineering approach to their properties and utilization. Harold DeWitt Smith. *Proc. Am. Soc. Testing Materials* **44**, 543–92 (1944).

The nineteenth Marburg Lecture. The author analyzes the physical properties and mechanical behavior of the important natural and synthetic fibers from an engineering standpoint of their use as structural materials. Effects of moisture, heat, and rate of loading on the mechanical properties of fiber materials are discussed and illustrated by charts. Influence of fiber dimensions on fiber behavior is also outlined. 14 tables and 19 charts. J.

Fiber Structure

Newer fibers. Paul Larose. *Can. Chem. Proc. Ind.* **29**, 476–9 (July 1945) (through *Bull. Inst. Paper Chem.* **16**, 11–12 (Sept. 1945)).

The author discusses the main physical requirements of textile fibers and the extent to which the molecular structure of natural and artificial fibers is important in determining their suitability for use in textiles. A molecular weight of 10,000 or more of the raw material is necessary if the fiber made from it is to have strength, insolubility, and general resistance to chemicals. The tenacity of the fiber increases with the degree of polymerization up to a certain degree, after which further polymerization is of little benefit. In addition to high molecular weight, if strength is desired, the macromolecules must be in chain form and the number of cross-linkages or the "netting" index must be low to produce a good fiber with flexibility and elasticity. The effect of the structure on the melting point is similar to that affecting strength. Melting the substance results in a reduction in the attraction between chains, thereby lowering the melting point. Water absorptivity and dyeing reactions are mainly controlled by the chemical nature of the substance; however, some structural features must also be taken into consideration. Oriented fibers do not take up dyes as readily as unoriented ones. If a fiber has not been uniformly drawn, it will show dark and light spots from the variation in dye affinity. Water solubility is largely controlled by the polar groups present. When solubility is too great, as with protein fibers, they must be stabilized by some kind of treatment, as by formaldehyde. Glass fibers, being of inorganic origin, do not exhibit the forces which come into play in organic fibers. Their main advantages are high tenacity and strength, and high resistance to heat and chemical reagents. Their extensibility and flexibility are very low; it is not possible to make a knot in glass yarn. In conclusion, brief reference is made to the fact that some important fiber properties do not depend on either chemical or physical structure, but on dimensions and configurations, such as diameter and shape of fiber, or whether made from a continuous filament or from staple fibers.

Stretch Spinning of Rayon

The increasing importance of stretching in rayon manufacture. Anon. *Silk and Rayon* **19**, 317, 319–20, 325 (Mar. 1945).

In recent years, one of the most significant developments in the production of synthetic fibers is stretching either during or after the spinning of the yarn as a means of improving its physical characteristics, notably tensile strength. This stretching process is now applied to all man-made fibers such as cellulose, cellulose acetate, protein, or synthetic polymers and resins. Fibers such as nylon, Saran, polythene, and vinyon are not suitable for most textile purposes without stretching, as it is by this treatment that they are given high tensile strength and a degree of stability to further stretching which is required in a textile fiber. Cellulose rayons are not easily stretched, as these fibers have low ductility; however, by employing a special viscose and coagulating bath with or without other baths, the strength of the yarn can be increased without impairing its elongation. With acetate rayon there are even more possibilities in stretching than with viscose or cuprammonium rayons; cellulose acetate can be highly stretched as such or it can at the same time be saponified so as to be converted either partly or wholly into acellulose rayon and thus yield the strongest rayon fibers so far obtainable. Although by stretching the fiber, the advantage of higher tensile strength is obtained, disadvantages are encounted such as decreased dye affinity, reduced elongation, increased luster, change of hand, and reduced pliability and resistance to shearing forces. However, some of these difficulties may be overcome by delustering, employing softeners and partial relaxation of the fibers. A. L. Merrifield

Synthetic Fibers

This month's progress in rayon and synthetic fibers. Anon. *Silk and Rayon* **19**, 533–6 (May 1945).

A brief discussion is given of the following subjects: (1) a new ripening process for making cellulose acetate rayon (B.P. 566,863); (2) producing wool-like fibers from acetate rayon (B.P. 566,504); (3) properties of viscose, Bemberg, and acetate rayon hosiery yarns; (4) application of fast-to-light pigments to cellulose fibers (B.P. 566,258); (5) an invisible universal marking ink for textile plants and laundries (B.P. 566,317); and (6) the manufacture of polythene fibers by the stretch spinning technique (B.P. 565,282).

A. L. Merrifield

Synthetic Fiber Properties

Properties of synthetic fibers. Anon. *Textile World* **95**, 117–32 (Sept. 1945).

A folded chart, 30 in. x 22 in. when opened, listing the method of manufacture, tensile strength, tensile stress, elongation at break, elastic recovery, average stiffness, average toughness, regain, water absorbency, specific gravity, dielectric strength; effect of heat, age, sunlight, acids, alkalies, other chemicals, organic sol-

vents, dyes used; resistance to moths and mildew; types and sizes produced; typical uses; producers and trade-names; and typical stress-strain curves of viscose, acetate, and cuprammonium rayon, nylon, vinyon, fiberglas, aralac, vinylidene, plexon, and synthetic rubber, together with an artist's drawing of the microscopic appearance longitudinally and in cross-section. Reprints are available from *Textile World*, 330 West 42nd Street, New York City, at 25 cents.

H. J. Burnham

Fibers and Fabrics—Production and Consumption

Statistics re production and consumption. *Rayon Organon* **16**, 131–45 (Sept. 1945).

A comparison is given for the years 1941 vs. 1945 of the distribution of rayon filament yarn by trades. Production figures are indicated for the period 1940–45 for women's fashioned hosiery. Production of broad woven fabrics (cotton, rayon, wool, and silk) for 1937 and 1939 is compared with that for 1943 and 1945. The monthly United States fiber consumption of cotton, wool, rayon filament yarn and staple fiber, and silk from 1920 to June, 1945, is shown by a percentage scale chart. Other pertinent data are given in tables. J.

Perforating Rayon Spinnerets

Improved methods for perforating rayon spinnerets. C. C. Downie. *Silk and Rayon* **19**, 440–1, 449 (Apr. 1945).

The holes in rayon spinnerets are expected to meet an exactitude which was not formerly required. More latitudes are permissible where an intermediate or temporary medium is employed during polishing, as this action sometimes is too severe. To receive the initial treatment, a "buffer" surface in the form of a strongly adherent plate is electroplated on the spinneret around the orifices before polishing. Metals of contrasting color to the spinneret are employed, such as copper on a gold-platinum alloy; thus details may be closely followed during processing. Ordinary plating methods are of little value for this work, because bubbles of gas expelled during the electrolysis would interfere with the exceedingly fine deposit which is formed in a limited space, but the electroplating can be performed in vacuum. The fine holes are reinforced with a synthetic resin which will not deform while the spinneret is being polished to the desired dimensions. On completing the polishing operation the resin plugs and metal-plating are dissolved out and the spinneret is ready for use.

A. L. Merrifield

Keratin Fibers

Keratin proteins yield better synthetic fibers. Anon. *Textile World* **95**, 99, 180, 182 (Aug. 1945).

Synthetic fibers made from keratin protein from such materials as feathers, horns, hoofs, and hair have been found to have a long-chain molecular structure locked in a linear position. They are said to be resistant to a limited extent when heated, to absorb water and swell readily without disintegration, and to be somewhat resistant to the action of micro-organisms and enzymes. A sodium alkyl aryl sulfonate in water solution is used as a solvent and a coagulating bath of acetone or acetone and salt solution follows the spinneret. The fibers are then stretched in steam to the extent of 300 to 400%. Tensile strength is said to be greater than that of wool and to approach that of silk. H. J. Burnham

Research on Wool

Textile research and the dominance of the wool fiber. A. F. Barker. *Text. J. Australia* **20**, 248–50 (Aug. 20, 1945).

The author challenges some of the published statements and conclusions by eminent scientists. For example, the statement ". . . that all fibers, whether industrially or biologically important, whether natural, regenerated, or synthetic, are members of one great family that must be studied as a whole." The author points out some of the characteristics of wool fiber which make it so different from any other. He also points to a marked difference in properties of merino, English, and cross-bred wools. The direction in which research should be carried is pointed out, and a plea is made for more applied research and more collaboration between the scientist and the technologist. The importance of proper control during the manufacturing processes is emphasized. J.

Hairiness in Wool

Distribution of hairiness in the fleeces of New Zealand Romney marsh ewe hoggets—Part I. H. Goot. *New Zealand J. Sci. and Technology* (A. Agricultural Section) **27**, 45–56 (June 1945).

The biological concept of hairiness is discussed and the conclusion arrived at that the hairiness should be looked upon as the end-product of prenatal checks. These checks are held to be responsible for structural development of fleece fibers, and their effect is capable of being measured by means of fiber-type-array technique and/or percentage of hairiness as ascertained by the medullometer. Statistical results are presented confirming the distribution of hairiness over the fleece and establishing certain relationships between the hairiness in different sampling positions or sums thereof. Regression equations are given for the estimation of the percentage of hairiness for the hind quarter, the side, the whole fleece, as well as for 14 of the sampling positions. Finally a suggestion is made for reducing the number of samples taken for routine benzol text examination of fleece hairiness from 6 or 18 to 1 hind-quarter position (position No. 5), thus considerably reducing labor, time, and money involved in the present routine. J.

Protein Fibers

Fibers from feathers and eggs. Anon. *Chemurgic Digest* **4**, 208–9 (June 30, 1945); cf. *B.I.P.C.* **15**, 426 (through *Bull. Inst. Paper Chem.* **15**, 478 (Aug. 1945)).

Reference is made to the research carried out in the Western Regional Research Laboratory for converting proteins from waste into fibrous materials.

Yarn Diameter

Effect of twist on cotton yarn diameters. Anon. *Am. Wool and Cotton Reptr.* **59**, 49, 51, 53 (Oct. 11, 1945).

An excerpt from a bulletin of the Lowell Textile Institute. An extensive study has yielded the formula for cotton yarns:

$$\text{yarn diameter} = \frac{0.0383}{\sqrt{\text{count}}} \times (1.275 - 0.055 \times \text{twist multiplier}).$$

H. J. Burnham

Rayon Yarn Exports

Rayon yarn exports: Some facts for critics. J. Guthrie Oliver. *Silk and Rayon* **19**, 545 (May 1945).

During the years following the start of the war, British exports of rayon yarns and cloth increased considerably over the period of 1934–38. Tables and figures show that prior to the war imports of those materials to the Dominions were supplied to a large extent by European countries and Japan. The loss of imports from these countries made it necessary for the United Kingdom to increase its exports of rayon yarn and fabrics to meet the minimum needs of the Dominions for civilian use.

A. L. Merrifield

Worsted Yarn Preparation

An important new development. Bill McComb. *Rayon Text. Mo.* **26**, 394–5 (Aug. 1945).

Yarns of a quality unequaled by the worsted system can be produced in only three steps from the card; viz., drawing, roving, and spinning. The process is limited to fibers of not more than 3 in., but within this limitation, it shows promise of making the present systems obsolete.

A. R. Martin

Weaving Cloths with Decorative Threads

Weaving cloths with decorative threads. J. W. Hutchinson. *Silk and Rayon* **19**, 538–9 (May 1945).

Yarns such as rayon and silk are often used in various ways for the "extra" decoration of cloths for apparel. These extra threads are usually woven from a separate beam for ease of control. Diagrams are given to illustrate two methods for the placement of the separate beam. Information is also presented on special methods necessary for weaving extra rayon, silk, and nylon threads into woolen fabrics.

A. L. Merrifield

Coated Fabrics

Preview of coated fabrics. Robert P. Magid. *Plastics* (Chicago) **3**, 53–6, 58, 143–5 (July 1945).

A discussion of an anticipated widely expanded market for the use of plastics-coated fabrics for many household uses. These fabrics are promising for use in draperies, upholstery, linens, lamp shades, closet accessories, and novel decorative treatments. A description of the various coatings and their properties is given. E. G. Martin

Industrial Fabrics

Industrial cotton fabrics. B. Monsaroff. *Can. Chem. and Process Ind.* **29**, 458–60 (June 1945).

Cotton is an excellent material for industrial fabrics because of its availability in large quantities, low price, strength, ease of processing, and durability under proper conditions. The chemical and physical properties of the fiber are reviewed and various limitations thereby imposed on manufactured articles are discussed. Some problems connected with making drier felts for paper machines are discussed.

E. G. Martin

Hot Air Drying

Air recirculation in drying of unbound moisture. V. P. Victor. *Chem. and Met. Eng.* **52**, 105–9 (July 1945).

The author points out that the drying performance is often limited by the inadequacy of the air supply. A graphical presentation of the drying potential of air under various conditions permits selection of economical conditions. The usefulness and theoretical basis for a number of "rules of thumb" are demonstrated and equations for design and checking dryer performance are presented.

Editors

Metallic Card Clothing

Metallic card clothing eliminates grinding and reduces stripping cycle. H. B. Robinson. *Textile World* **95**, 102–3 (Oct. 1945).

A report on the use of metallic card clothing at Columbus Mfg. Co., Columbus, Ga. Some of this type has been in use for 17 years and the cards so equipped have never been ground. Cards are stripped once every two weeks. It is said that there is no appreciable difference in the quality of yarn made from cotton carded by metallic and regular clothing. H. J. Burnham

Loom Studies

Electric strain gage promises solution to textile machine problems. V. E. Hillman. *Textile World* **95**, 104–6 (Oct. 1945).

A description of the use of strain gages in studying stress in various loom parts. A cathode-ray oscillograph and a motion picture camera are used to record the intensity of the stresses. H. J. Burnham

Rayon Knitwear

Factors which influence the color and finish of viscose rayon knitwear. Anon. *Silk J. Rayon World* **21**, 33–4 (May 1945).

Practical. R. K. Worner

German Rayon Plant

Processing of rayon staple in German pilot plant. Anon *Am. Wool and Cotton Reptr.* **59**, 13, 42 (Oct. 18, 1945).

An outline of the equipment and methods used at a model staple fiber pilot plant of the Zellwolle Lehrspinnerei at Denkendorf, Germany. A bale breaker feeds stock into bins, where it is conditioned for 24 hrs. The picker uses one Kirschner-type beater and the first 2 or 3 grids are removed. One card has metallic clothing embedded in a fabric or

rubber base. Every second or third flat is removed and a smooth plate is inserted in its stead. Card production is 10 lbs. per hr. Two processes of drawing are used with 8 ends up on each, followed by 2 processes of roving. An air suction device is used on spinning in place of the scavenger roll. An automatic tow cutting machine makes an overlay or shingle effect of the cut staple on an apron which carries it to an intersecting gill box. H. J. Burnham

MISCELLANEOUS

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Atmospheric Conditions

Atmospheric conditions in cotton textile plants. Philip Drinker. *Textile Bulletin* **69**, 17, 18, 20, 22 (Oct. 1, 1945).

A report of a study for the Division of Labor Standards, U. S. Dept. of Labor, into temperature, humidity, lint, and dust conditions in cotton mills with respect to the health and working efficiency of operatives. The study finds nothing inherently unhealthful about the industry. However, rest rooms, toilets, cafeterias, etc., are found to be under the standard of other industries.
H. J. Burnham

Cotton-Gin Presses

Standard-density cotton-gin presses. Charles A. Bennett, J. E. Harmond, and Charles S. Shaw. *Circular No. 733*, U. S. Dept. of Agriculture (Aug. 1945).

General requirements, specifications, and construction details are given; also specifications for conversion of low-density gin presses for standard-density service. J.

Cotton Manufacture in California

Report on cotton textile manufacturing in California for the San Joaquin Valley Association of Commercial Organizations. Lockwood Greene Engineers, Inc. Visalia, Calif., Tri-County Cotton Textile Committee, May 1, 1945. 49 pages.

Previous investigations of cotton textile manufacturing prospects on the Pacific Coast have led to adverse conclusions. This report states that conditions have become more favorable because of increasing population, reduced wage differentials between the East and the Pacific Coast, development of textile finishing plants in the Far West, and the growth of the garment-making industry in this region. The latter offers a local market for high-grade fabrics such as are made of California cotton. Construction by local capital of a pilot mill having 15,000 spindles and 400 looms, at an estimated cost of $2,500,000, is proposed. It is recommended that the mill begin on simple twills and denims, later attempting more elaborate fabrics such as drills, gabardines, poplins, and seersuckers, as the demand indicates. The report surveys markets, labor, power and heat, water, taxes, and possible locations for a mill in California, and gives equipment and floor plan for the proposed mill. R. B. Evans

Cotton Transportation Costs

Raw cotton and cotton linters: A report by the Subcommittee for Economic Study, Railroad Committee for the Study of Transportation. Washington, D. C., Association of American Railroads, 1944. 100 pages.

This report is the first of a series and is to be followed by similar reports on wool and mohair, raw silk, synthetic fibers, textiles, and leather. The purpose of these studies is to estimate future railroad traffic to be expected from the fiber and textile industries and to point out relevant factors. In 1942, 227,400 cars of cotton originated on Class I railroads in the United States, paying a total of $42,075,000 in freight charges. Additional freight revenue was derived from linters and cottonseed, and from cotton textiles. The effect of developments in cotton production, marketing, consumption, and the export-import situation, and of competition from water and truck transportation, on tonnage, and revenue derived by railroads from cotton is discussed. It is concluded that approximately 12.5 million bales of cotton will be moved annually by all forms of transportation during the first three or four post-war years. The text of the report is documented with numerous tables, charts, and maps.
R. B. Evans

Electronics

Electronics at work for textiles. Harold E. Reed. *Textile World* **95**, 83–90 (July 1945).

Potential applications of electronics in the textile industry are outlined. According to a survey by the McGraw-Hill Publishing Co., mills want electronics applied to control of humidity, doors, motor speed, counting and inspection, and safety devices. An extensive chart is presented listing the type of electronic devices which can be applied to each processing operation in textile mills based on present and experimental use and on present knowledge.
H. J. Burnham

Flax Processing

Flax processing: the need for research. W. L. Greenhill. *J. Council Sci. Ind. Research* **18**, 132-40 (1945) (through *Chem. Abstr.* **39**, 4489⁹, Oct. 10, 1945).

The results of flax-processing studies over the past 7 years are briefly reviewed and a program for future research is presented.

German Chemical Developments

Developments in the German chemical industry. Industrial Intelligence Staff, Chemical Warfare Service. *Chem. and Eng. News* **23**, 1516–22 (Sept. 10, 1945).

A general report is presented of the more important findings of military and civilian intelligence teams which have been inspecting and investigating the German chemical industries' activities. Extensive use was made of acetylene in the synthesis of a wide variety of polymerizable monomers and other aliphatic compounds. Important catalysts employed were alkali alcoholatcs, zine (or cadmium) salts of organic acids, copper (or silver acetylide), and nickel car-

bonyl. With the former, vinyl ethers of long-chain alcohols were prepared, the polymers of which were used as textile assistants and sizes, adhesives, wood and fiber impregnants, plasticizers, etc., and, together with synthetic detergents, as textile finishing agents, wetting agents, dyeing assistants, lubricants, printing assistants, leveling agents, etc. The addition of about 25% of sodium carboxymethyl cellulose to synthetic detergents was found to increase their effectiveness to fully the equivalent of that of soap. Water-resistance of cellulosic fibers was attained by treating with hexamethylene di-isocyanate or by using an emulsion of paraffin wax containing zirconium oxychloride (resistant to washing) or aluminum acetate (not fast to washing). A claim was made that treatment with di(hydroxymethyl)phenols produced permanent water-repellence. Of the synthetic tanning agents, one was prepared by condensing 4,4′-dioxydiphenyl sulfone, formaldehyde, and the alkaline waste liquors from cellulose treating plants. Polyurethanes, especially linear polymers of 1,6-hexamethylene di-isocyanate and 1,4-butanediol, were used as plastics and as new textile fibers. In the latter use they were considered to be equal to nylon in most respects and superior in water absorption and dyeing characteristics. Special acid- and chemical-resistant fibers were woven of polyvinyl chloride (chlorinated and unchlorinated) and also of polyethylene fibers. Improvements were made in the process for making cellulose acetate and regenerated cellulose and to speed up the viscose cycle. The cuprammonium process was also greatly improved with respect to both ammonia and copper (cheap and quantitative) recovery. Among the insecticides, triphenyl-3,4-dichlorophenyl phosphonium chloride was developed as a moth repellent, particularly resistant in textiles to washing, and also 3,4-dichlorophenyl-N-methyl sulfonamide. Prehydrolysis of beechwood with 2.5% sulfuric acid and production of yeast from the hydrolysis liquors were combined with treatment of the wood residue by the Kraft process to produce a pulp of 96% alpha content. Where waste or cheap nitric acid was available, 98% alpha pulp suitable for acetate silk was produced. Binder twine made from wet-strength treated sulfate paper had successfully replaced sisal. Cellulose was being reduced with hydrogen at high pressure and 160° C to produce a mixture of glycerol and glycols. A glycerol substitute for most purposes except explosives was produced by hydrogenation of invert hexose. In the extensive field of dye chemistry many definite improvements in technique and synthesis were discovered. Numerous other developments are reported such as the oxidation of paraffins obtained from the hydrogenation of brown coal, lignite, or carbon monoxide to produce fatty acids from C_1 to C_{24} and the large-scale production of 80–85% hydrogen peroxide.

E. F. Evans

Hazardous Chemicals

Table of hazardous chemicals. Anon. *Chem. and Eng. News* **23**, 1248–56 (July 25, 1945).

A revision of the table prepared by the N.F.P.A. Committee on Hazardous Chemicals in cooperation with the American Chemical Society. Table lists name, usual shipping container, fire hazard, life hazard, method for storage, and best fire-extinguishing methods for the common hazardous chemicals. J.

Egyptian textile industry

An Egyptian industry. Anon. *Foreign Commerce Weekly* **21**, 7, 39 (Sept. 29, 1945).

Most important textile enterprise in Egypt is Misr Cotton and Wool Spinning and Weaving Mill, located 75 miles northwest of Cairo. The enterprise includes cotton, wool, and flax mills, ginneries, and related plants, equipped with machinery mostly of American or British manufacture. About 75 tons of cotton are consumed daily in manufacture of yarn, thread, cloth, and knit goods. The wool section, which was opened in 1940, uses 150 tons of Australian and Egyptian wool annually in the manufacture of yarns, suitings, blankets, and other products. The flax section is small, consisting of 4,000 spindles and 300 looms, and consumes 400 tons of flax annually in the manufacture of table coverings, men's suits, and jacquard cloth. The entire enterprise is capitalized at the equivalent of $4,000,000. In 1944 it paid in wages more than $6,000,000, and earned profits reported at more than $16,000,000. R. B. Evans

Graphical Methods in Cost Accounting

Process economic analysis aided by new graphical method. M. M. Reynolds. *Chem. and Met. Eng.* **52**, 104–6 (Aug. 1945).

Graphical methods for showing the relationship between costs and profits in the production of industrial products tend to become extremely complex when a considerable number of variables are involved. Employing a little-known geometric device whereby addition and subtraction can be accomplished graphically with triangular charts, the author has introduced a novel graphical method enabling several variables to be handled readily; one of the problems, for example, has five variables, including raw materials, by-products, and finished product. Editor

German Plastic Developments

Plastics developments in Germany. G. M. Kline. *Chem. and Eng. News* **23**, 1615 (Sept. 25, 1945).

German manufacturing processes, fabricating techniques, methods of polymerization, and diversification of types of polymers were similar to those in the United States. Among the new or less well-known polymers are polyvinyl ethers, polyvinyl carbazole, polyethyleneimine, and polyurethanes. In the condensation resin field special compositions and catalysts have been developed for phenolic, urea, melamine, aniline, and alkyd resins. The polyurethanes were in use in Germany for the manufacture of fibers, bristles, adhesives, artificial leather, injection molding compounds, and plastic foams. The polyvinyl ethers were used as lacquer constituents, adhesives, and impregnating agents for paper and textiles. Polyethyleneimine was used as a paper impregnant. It greatly im-

proves the wet strength and scuff-resistance of soft crepe paper without detracting from the absorbency and was therefore used for towels, bandages, and shoe insoles.

E. F. Evans

I. G. Farben Research Reports

Index of I. G. Farbenindustrie research reports. Anon. *Chem. and Eng. News* **23**, 1846–8 (Oct. 25, 1945).

A list is given of 334 research reports of the I. G. Farbenindustrie. Microfilms of the complete reports, in German, are to be made available by the Office of the Publication Board, Department of Commerce.

E. F. Evans

Jute Economics

Statistics on jute and jute manufactures, with a brief survey of the industry. Horace G. Porter and Maurice R. Cooper. Washington, Bureau of Agricultural Economics, U. S. Department of Agriculture, June, 1945. 116 pages.

During 1934–38, net imports of jute and jute manufactures into the United States averaged 775 million pounds a year, or the equivalent in weight of more than 1.5 million bales of cotton. Jute comprises 16% of the total fiber made available for use by ultimate consumers in this country, as compared with: cotton, 60%; wool and hard fibers, each 8%; rayon, 6%; silk and flax, each 1%; and hemp, less than 0.5%. About 80% of the jute imported into the United States is in manufactured form, mainly burlap, but raw jute is imported and used by the twine, furniture, carpet, meat packing, and rubber industries. History of the jute industry and the effect of World War II on it are discussed. An extensive glossary of jute terms is given. Statistics on production, international trade, consumption, stocks, and prices of jute and jute manufactures are given in 109 tables.

R. B. Evans

Labor in English Cotton Mills

Cotton labour training problems and solution. J. Baines. *Text. Mfgr.* **71**, 322 (Aug. 1945).

English textile mills, as they reopen, face a decided shortage of labor. Wartime classes of new employees have been small, juveniles do not want to enter industry, and many pre-war female employees who have been employed in war industries are retiring. Inexperienced adults will be the main source of labor supply. Separate training sections in mills with full-time instructors are recommended. Work elements involved in jobs should be analyzed and studies should be made of the performance of efficient operators. In the training program, lectures should be followed by demonstrations and then by short periods of machine operation under observation. R. B. Evans

Industrial Waste

Industrial waste. An important factor in process planning. Anon. *Chem. and Met. Eng.* **52**, 117–24 (Aug. 1945).

As a result of the rapid growth of chemical industries, the effects of pollution due to waste disposal have increased greatly. The existing and pending state and Federal anti-pollution legislation is reviewed. Several industry-wide organizations exist to study this problem. The main types of waste and methods for treating them are discussed.

E. D. Klug

Post-Form Molding of Laminates

Hot-forming laminated phenolic plastics. E. Perry. *Brit. Plastics* **17**, 279–82 (July 1945).

The technique of hot- or post-forming laminated phenolic plastics into intricate shapes led to the development of Micarta 444, a special laminated phenolic plastic which retains its unusual properties after the forming process. Details of the technique for use of Micarta 444 and tables of its physical properties in comparison with plywood and metals are given. E. F. Evans

Infra-Red Heating

Infra-red heating. T. A. Roberts and G. J. Happerfield. *Brit. Plastics* **17**, 302–5 (July 1945).

A brief description of the pre-heating of molding powders with infra-red rays. E. F. Evans

Magnesium in the Textile Industry

Magnesium in textile equipment. M. M. Moyle. *Modern Metals* **1**, 4–6 (1945) (through *Chem. Abstr.* **39**, 4491[9], Oct. 10, 1945).

Applications and advantages are discussed.

O. P. B. Publications

Scientific information from government-sponsored research and enemy sources being released. Anon. *Chem. and Eng. News* **23**, 1720–4 (Oct. 10, 1945).

A classified and descriptive list of 388 reports now available from the Office of the Publication Board, Department of Commerce, is given, including such topics as dyes, insecticides, plastics, rubber, wood, pulp, paper, etc. E. F. Evans

Scientific Information from Germany

Scientific information from enemy sources. Anon. *Chem. and Eng. News* **23**, 1849–50 (Oct. 25, 1945).

A classified and descriptive list is given of reports released since the previous listing (cf., preceding abstract) together with prices.

E. F. Evans

Silicones

New Dow-Corning plant produces silicones at Midland. W. R. Collings. *Chem. and Eng. News* **23**, 1616–19 (Sept. 25, 1945).

Three-fourths of the silicone production at the Midland plant, the layout and construction details of which are briefly described, is Dow-Corning No. 4 electrical insulating paste, previously produced under military secrecy. It is a smooth, homogeneous, colorless grease, or paste, which is not only moisture-resistant and non-hygroscopic, but surfaces of metal, ceramics, or rubber, once treated with it, become water-repellent. It does not harden, crack, or flow at any temperature from

−40° to over 400° F. It does not air-dry or harden on baking, is a very good dielectric, and has excellent resistance to arcing. The liquid silicones are outstanding for their low freezing points and their extremely low change in viscosity with temperature. They can be made in almost any desired viscosity and have found use as vibration damping liquids, as high dielectric fillers, and as dashpot fluids. Small amounts of certain silicone liquids, added to lubricating oils having a tendency to foam, eliminate such characteristics. A silicone rubber, Silastic, is noteworthy for its relatively unchanged physical properties from low to very high temperatures. It can be used to laminate Fiberglas or asbestos for gaskets and can be extruded over wire. Special lubricating greases have been developed which will operate hundreds of hours at temperatures of 150° to 175° C. Weather- and heat-resistant coatings, such as silicone baking resins and aluminum powder, have been tested on boiler stacks and fronts, Diesel engine mufflers, and small gas furnace stacks with performance exceeding that of other types of coatings.

E. F. Evans

Preparation of Sodium Alginate

Colloids from kelp give rise to a unique process industry. C. K. Tseng. *Chem. and Met. Eng.* **52**, 97–100 (June 1945).

Methods for harvesting kelp and recovery of sodium alginate from it are described. The major use of this product is to impart smooth body and texture to ice cream. Other uses are as a thickening agent and protective colloid. E. D. Klug

Wages in Rayon Industry

Wages in the rayon industry, May, 1944. Willis C. Quant. *Bulletin No. 806* of the United States Bureau of Labor Statistics, Department of Labor. Washington, Government Printing Office, 1945. 17 pages. Price, 10 cents. (Also in *Monthly Labor Review* **59**, 1141–57 (Dec. 1944)).

Rayon industry consists of 28 plants employing 55,000 workers, of which more than two-thirds are employed by four companies, and of which about three-fourths are employed at plants having union agreements. Wage data are presented for 58 key occupations. Variation in wages with occupation, length of service, overtime, and incentive plans is discussed. R. B. Evans

Quality Control

Quality control by statistical methods. A. E. Dennis. *Rayon Textile Monthly* **26**, 397–9 (Aug. 1945).

An address. A. R. Martin

Selection of Mill Inside-Colors

Color in the plant. Faber Birren. *Du Pont Magazine* **39**, 10–16 (Oct. 1945).

A discussion of the use of color for wall interiors. Restraint, control, and direction in the use of colors is necessary and some of the dangers inherent in their use are pointed out. Practical hints are given. Illustrations in color indicate its proper use. J.

Vacuum Molding

Vacuum molding. Anon. *Brit. Plastics* **17**, 277–8A (July 1945).

A brief description is given of several applications of the vacuum molding technique. E. F. Evans

Wood Plastics

Wood plastics. E. C. Sherrard, E. Beglinger, and J. P. Hohf. *Brit. Plastics* **17**, 272–6 (July 1945).

Wood, from which some of the cellulose has been removed by either acid or aniline hydrolysis, combined with a suitable plasticizer yields a composition which can be readily molded to yield black, lustrous, and strong articles. Typical acid and aniline hydrolysis procedures are given, as well as molding compositions and conditions. Ketones, aldehydes, amines, ethers, esters, anhydrides, amides, wood-tar oils, or resins may be used as plasticizers. As little as 25–30% phenolic resins with pretreated wood produce molded compounds comparable to general-purpose powders containing 45–50% resin. The wood-plastic products have high shock and weather resistance, are unaffected by ultraviolet light, can be painted, veneered, or lacquered, and can be molded about relatively heavy metal inserts.

E. F. Evans

PATENT REFERENCES

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Upholstering Fabric

Upholstering fabric. William D. Hedges, John C. Lowman, and Thomas J. Kerr (to Columbus Coated Fabrics Corp.). U. S. 2,387,396 (Oct. 23, 1945).

A coated upholstery fabric material comprising a fabric base having a flexible coating consisting of the evaporation residue of a mixture consisting of 10 parts by weight of nitrocellulose, plasticizing resin consisting of 16 parts by weight of a condensation product made up of 800 parts by weight of castor oil, 50 parts by weight of maleic anhydride, and 26 parts by weight of glycol, and 7.5 parts by weight of a condensation product made up of 1,000 to 1,200 parts by weight of castor oil, 26 parts by weight of diethylene glycol, and 50 parts by weight of maleic anhydride, 7.5 parts by weight of pigment and 40 parts by weight of solvent.

Sizing and Finishing Compositions

Permanent organdy finish. Fred G. La Piana and Herman S. Bosland (to Stein, Hall & Co.). U. S. 2,385,714 (Sept. 25, 1945).

A sizing or finishing composition containing starch, a water-soluble potentially water-insoluble urea-aldehyde compound, and a water-soluble polyvinyl composition, applicable to fabrics by conventional methods, producing a crisp, stiff, permanent finish, similar to that of an organdy. P. T. I.

Finishing Pigment-Resin Colored Fabrics

Fabrics colored with pigment-resins may be improved in fastness to washing, crocking, and sloughing, by a simplified method. Ralph D. Greene, Roy H. Kienle, and Richard D. Vartanian (to American Cyanamid Co.). U. S. 2,385,320 (Sept. 18, 1945).

The object of this patent is to provide a novel, simple, and effective process to render fabrics dyed or printed with pigment-resins more nearly permanently fast to washing, crocking, and sloughing, by after-treating with an aqueous solution of a water-soluble amidaldehyde-type resin which has been etherified with a polyhydric alcohol, drying, and curing the applied resin to eliminate its water-soluble properties, resulting in a permanent finish. Fabrics so treated are stated to have excellent wash-fastness and a marked improvement in both dry and wet crock-fastness without any appreciable change in pliability or hand.

P. T. I.

Guanamines in Textile Finishing

Improved finishes with guanamines, for all textile fibers. Jack T. Thurston (to American Cyanamid Co.). U. S. 2,385,766 (Sept. 25, 1945).

A new class of textile finishing agents containing N-substituted guanamines and their reaction products, with improved softening, waterproofing, and other properties applicable to practically all textile fibers by new and improved methods.

P. T. I.

Textile Finishing

Alkyl guanamines in textile finishing. Jack T. Thurston (to American Cyanamid Co.). U. S. 2,385,765 (Sept. 25, 1945).

A new class of textile finishes is described which contain higher alkyl guanamines and their aldehyde condensation products, and possess improved water-resistant and softening properties, applicable to practically all textile fibers. P. T. I.

Fabric Coatings

Coated fabric material. William D. Hedges, John C. Lowman, and Thomas J. Kerr (to Columbus Coated Fabrics Corp.). U. S. 2,387,394 (Oct. 23, 1945).

A flexible coating and method of application to fabrics is described which is said to retain its pliability and flexibility at extremely low temperatures, that the coating will not stiffen or exude at temperatures of 185° to 200° F, and will not crack or spew when subjected to weathering. It is composed of a nitrocellulose film-forming constituent, and a plasticizer is made up of the reaction product of castor oil and maleic anhydride and glycol.

Treatment of Textile Materials

Composition for the sizing of rayon (regenerated cellulose), and acetate rayon (cellulose acetate). George W. Seymour and Dustin Y. Miller (to Celanese Corp. of America). U. S. 2,385,110. (Sept. 18, 1945).

This invention claims a sizing composition of polymerized methacrylic acid and derivatives, polymerized ethylene oxide, a wetting or penetrating agent, and water, which when applied as a sizing to rayon by conventional methods will overcome such difficulties as fraying, chafing, and degradation of the yarn during weaving by minimizing friction.

P. T. I.

Wool Treatment

Unified process for treating wool. Wallace Paul Heintz and Walter Hardie Zillessen (to E. I. du Pont de Nemours & Co., Inc.). U. S. 2,387,510 (Oct. 23, 1945).

The invention is concerned primarily with a process which effects in one treatment the functions of lubrication of the loose wool, prior to carding, and of a fulling agent. An object of the invention is to provide a process which will avoid treatment of the wool with soap, mineral oil, or other agents which are difficult to remove from the finished product. A further object is to coordinate the chemical treatment of wool at its various stages of mechanical treatment—namely, carding, spinning, weaving, and fulling, whereby a single chemical treatment prior to the first stage may suffice for all subsequent treatments. A still further object is to modify the processing of wool in such a manner as to produce a yarn of superior quality in the intermediate stage, and a finer and all-around superior finished fabric.

Textile Printing Composition

Greige goods printing. St. Clair Smith. U. S. 2,385,737 (Sept. 25, 1945).

This patent is pertinent to the printing of greige goods, successfully accomplished by using a printing composition comprised of a resinous binder dissolved in a volatile solvent, and a terpene ether which it is stated will eliminate any resist due to sizing, oil, or natural waxes ordinarily present in greige goods or materials unprepared for printing.

P. T. I.

Laminated Plastics

High-strength laminated amino plastics. Kurt E. Ripper (to American Cyanamid Co.). U. S. 2,388,184 (Oct. 30, 1945).

The invention claims a practical method for using amino plastic resins in connection with laminations of textile fabrics, paper, or glass cloth.

Printing Composition

Compositions for printing and coloring flexible materials such as fibers, fabrics, and the like. Ro Herman Kienle and Alfred Loui Peiker (to American Cyanamid Co.). U. S. 2,383,937 (Sept. 4, 1945).

The invention is concerned with the printing of textiles. The statement is made that if the water-in-oil type emulsions are prepared incorporating rubber or similar elastomers it is possible to cause sufficient flow to give uniform blotch printing without destroying the sharpness of print outline, and thus shallow engraving can be employed and an excellent

blotch type designs more satisfactorily, but, according to this invention, the use of such emulsions for printing different types of designs at the same time from the same roll is permitted because of the added slight flow characteristics and increased film flexibility of said emulsions. P. T. I.

Yarn Twister

Albert E. Winslow (to Farrel-Birmingham Co., Inc.). U. S. 2,385,046 (Sept. 18, 1945).

This invention relates to a yarn-handling machine and more particularly to the ring twister type. One of its objects is to reduce contact with the yarn, which may cause breakage of the yarn or fibers composing the yarn. The machine twists the yarn back to the supply package, thereby binding in all loose ends, and when parallel yarns are used to assist in their separation. P. T. I.

Knitted Fabric

Albert E. Page (to Scott & Williams, Inc.). U. S. 2,384,392 (Sept. 4, 1945).

A knitted stocking with a self-sustaining top with a corrugated back that will grip the leg. The fabric is a combined rib and plain-course fabric. P. T. I.

Weaving, Transporting, and Finishing Cloth

Arnold Eddy (assignor of one-half to Hilda W. Striker). U. S. 2,384,288 (Sept. 4, 1945).

This invention relates to improvements in cloth beams to facilitate the transporting and finishing of cloth without unwinding cloth as woven in the loom, but by means of a new cloth beam construction that will facilitate removal of cloth roll from the cloth beam, and sliding of this cloth roll onto another beam. P. T. I.

Stop Motion Device

Theodor Van Heek. U. S. 2,384,357 (Sept. 4, 1945).

An invention that will stop the loom when the cloth is so delivered to the cutting knife as to be in a position that would cause the knife to tear the fabrics. Any cause that would render imperfect cutting of the fabrics on the loom is covered as to cause the loom to stop. P. T. I.

Stopping Means for Looms

Carl D. Brown (to Draper Corporation). U. S. 2,383,931 (Sept. 4, 1945).

A stop motion for automatic looms that provides a simple and effective means for stopping the loom within a minimum number of mechanical connections upon the occurrence of filling failure. P. T. I.

Loom

Saint Julian Geddings. U. S. 2,384,909 (Sept. 18, 1945).

This invention has special reference to means for operating the clutch in the driving and stopping of the loom. P. T. I.

Shuttle

James Gardiner Allen and Antonio Villani (to Draper Corporation). U. S. 2,385,048 (Sept. 18, 1945).

An invention relating to automatically threading shuttles for looms, particularly side delivery eyes of such shuttles. This invention provides a side delivery eye that will trap the filling thread, preventing it from moving upward and unthreading the shuttle. P. T. I.

Shuttle

Heinz Menking (to Aluminum Company of America). U. S. 2,385,718 (Sept. 25, 1945).

An invention relating to shuttles, made of metal, especially magnesium and the alloys in which it predominates and preferably the alloys containing at least 80% magnesium by weight. Various applications of the use of magnesic metal for the body and coatings of various types are stated to give a light and at the same time a strong shuttle having high resilience. P. T. I.

Shuttle

Carl D. Brown (to Draper Corporation). U. S. 2,385,756 (Sept. 25, 1945).

This invention relates generally to shuttles for automatic looms, and more particularly to threading devices for such shuttles. P. T. I.

Thread Holder for Looms

Herbert A. Whitin (to Crompton & Knowles Loom Works). U. S. 2,385,242 (Sept. 18, 1945).

An invention to provide a self-adjusting thread holder for weft ends for weft replenishing looms. P. T. I.

Electrical Weft Detector for Looms

Richard G. Turner (to Crompton & Knowles Loom Works). U. S. 2,384,979 (Sept. 18, 1945).

Improvements in weft detectors so as to facilitate assembly and also removal of the detector elements. The feature of this invention is to make the elements into parts that can be separated or removed, in contrast to customary detectors, which are so made that removal of defective parts requires considerable time. P. T. I.

Controller Mounting for Knitting Machines

Edward Vossen (to Stop-Motion Devices Corp.). U. S. 2,385,174 (Sept. 18, 1945).

An improved controller mounting which is exceptionally efficient and fast in operation, which may be manufactured, sold, and installed at a relatively low cost. P. T. I.

Straight-Bar Knitting Machine

Thomas Charles Bromley and Arthur Shortland (to Mellor Bromley & Co., Ltd.). U. S. 2,384,154 (Sept. 4, 1945).

Improvements in straight-bar knitting machines, wherein sinkers are moved in unison by means of a catch bar. P. T. I.

Textile Research Journal

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SUPPLEMENT TO

TEXTILE RESEARCH JOURNAL

VOL. XV, No. 12 December, 1945

Annual Report of the President
Textile Research Institute, Inc.

Harold DeWitt Smith

Read at Sixteenth Annual Meeting of the Institute, November 9, 1945

To the Members of the Textile Research Institute:

This has been a constructive year for T. R. I. The specific accomplishments of our operating divisions are recounted in some detail in the divisional reports which are being presented to you today.

We have done and are doing scientific textile research; we have established a scientific and technical textile journal of high quality; we have five graduate students working for their doctor's degrees as T. R. I. Fellows on fundamental textile research problems; we have administered for the Textile Foundation an economic research project; we have held sectional research meetings; and, last but not least, we are converting our building in Princeton into a research laboratory, the basement and first floor of which should be ready for use before the first of January.

The year has also been constructive with respect to the evolution of policy and organization as a result of much thinking, debate, and decision on the part of your officers, your Board, and your staff in their efforts to interpret the will of the members in pursuing the Institute's goal of service as the industry-controlled instrument through which all sections and all branches of the textile industry can collaborate on the conduct, the encouragement, and the publication of textile research.

This report covers the fiscal year from October 1, 1944, to September 30, 1945, except where mention is specifically made of data or activities up to the date of this meeting. The Institute's affairs were administered by Mr. F. S. Blanchard in the double capacity of President and Executive Secretary until his resignation on January 19, at which time, by action of your Board, I assumed the honorary office of President, basing my acceptance on the provision that I be released as soon as a suitable executive head could be employed, and, in any event, not later than the date of this meeting.

It was evident to us all at that time, and has been confirmed by subsequent experience, that the administration of the Institute's affairs cannot be adequately discharged by an honorary president, whose primary interest and responsibility lie elsewhere. Emergency wartime duties of the committeemen, whom I appointed to select a candidate for the position of salaried executive head, and also the dearth of suitable candidates caused by the general manpower shortage, delayed the selection of such a person. During recent weeks, consultation with a number of our company members has resulted in the suggestion

of several names which will be referred to the new Board of Directors for their consideration and action.

Under the By-Laws, which are being presented for your approval and action today, the honorary office of president is transformed into the honorary office of Chairman of the Board, and the office of President, which I am vacating, becomes the top paid staff position. It is clear that the most important single step in the further successful development of the Institute is the employment of an able president, and I feel sure that your new board will make this its first order of business.

Meetings

Some measure of the time and effort which your officials have devoted to the work of the Institute since the fifteenth annual members' meeting in November, 1944, is indicated by the fact that the Board has held eleven meetings, the Executive Committee has held ten meetings, and meetings of other committees of the Institute total twenty-five.

Membership

The progress of our membership work during the past fiscal year is summarized in the table below.

Almost all of the gain in company membership occurred during the period of Mr. Blanchard's incumbency as President, and as Membership Secretary. I am glad to record here the Institute's gratitude for this important service.

Much of the increase in individual memberships can be ascribed to interest in our JOURNAL in its revitalized form, and credit for this is due to the excellent work of our Publications Department under the direction of Mr. Jacobs. In both classes, the effort and support of Major MacMaster, first as membership representative and subsequently as Acting Secretary of the Institute, contributed much to the results.

Members	Oct. 1, 1944	Resigned	Elected	Sept. 30, 1945	Income from dues as of Sept. 30, 1945
Sustaining	1	—	—	1	$ 10,000
Company (Active)	154	12	57	199	92,600
Individual (Associate)	351	23	92	420	4,200
Life	1	—	—	1	—
Total	507	35	149	621	$106,800

We have held the interest and support of almost all of the membership which we had at the beginning of the last fiscal year, and have registered a substantial growth during the year. A number of the individual resignations are due to the fact that these individuals became eligible to receive the JOURNAL as one of the five representatives of a new company member. The relatively static state of membership growth during the last several months points clearly to the need for resumption of vigorous membership work by personal contact with prospective members.

Mr. Hopkins, our Research Director, has made a very valuable study of our company membership list, and of a list of approximately 300 non-member companies who are engaged in or associated with the textile industry. This study comprises an analysis and classification of the companies with respect to the maintenance of laboratories and technical personnel and with respect to the status of such technical personnel as individual members of our Institute and of several textile technical societies. The study reveals that about 70 percent of our company members were not listed (in 1940) as having research laboratories. This suggests that a rather large percentage of our membership is perhaps not yet in a position to support technical activities or equipped to profit by fundamental research or even basic applied research. Inasmuch as one of the primary purposes of the Institute is to promote and facilitate the use and value of research in the textile industry, I am pleased that we have secured and maintained the support of many companies which are not yet engaged in their own research, because I feel that their continued interest in the Institute will not only help them to develop technically, but will be valuable in guiding the Institute along the path of its service to the industry. Mr. Hopkins' analysis of non-member companies provides a very constructive basis for our future membership work.

An analysis of our present membership by industry branches, which is given in the next table, reveals that our members are rather well distributed throughout the various branches of the industry.

Organization

As a result of the recommendations of the Special Survey Committee, which reported to your Board in January, 1945, an interim organization of departmental administration by committees was established pending the employment of an executive head. In

	Percent of total Company Members	Percent of total Company Membership dues
Cotton mills	22%	29%
Suppliers	19%	8%
Woolen and worsted mills	13%	19%
Finishers	8%	7%
Carpet mills	6%	10%
Rayon producers	6%	15%
Knitting mills	5%	4%
Selling houses	5%	1%
Thread mills	4%	4%
Testing laboratories	3%	1%
Machinery makers	2%	1%
Miscellaneous	7%	1%

that same month a By-Laws Committee (comprising Dr. Fred Bonnet, Chairman, Mr. Earl Constantine, and Mr. R. W. Vose, and assisted by Mr. A. M. Webster of the legal staff of the American Viscose Corporation—through whose courtesy he contributed his services—and Mr. Buttle, the New York attorney whom the Institute employed to insure that the changes in the By-Laws and the Charter would conform to the laws of the State of New York) began to study our By-Laws with the idea of recommending certain revisions. This work developed into a very thorough study of the whole question of organizational structure and resulted in the complete set of By-Laws (and some minor revisions in the Charter in order to make it consistent with these By-Laws) which are presented for your action today.

In essence, these By-Laws provide a straightforward, simple corporate plan of organization, under which the Company Members elect a Board of Directors. This Board elects a Chairman of the Board, and a President, and other officers of the Institute. The President is vested with the responsibility of managing the affairs of the Institute for the benefit of its members, with authority and freedom within the policies established by the Board.

In the course of its work, the By-Laws Committee prepared eleven tentative drafts of the By-Laws. I wish to record the Institute's gratitude for this thorough and painstaking task and to recommend the new By-Laws for your approval as a sound, practicable plan of operating the Institute.

Accounting

Because the magnitude and the diversity of the Institute's financial transactions had outgrown the simple bookkeeping system which was adequate in its earlier days, an accountant, Earl R. Edmunds, was employed in February to set up books of accounting, which would be adequate for our present and our future requirements. Under the able guidance of Major MacMaster, and with the assistance of Mrs. Ritch, our bookkeeper, a bookkeeping system was established and entries recorded back to October 1, 1944. Since March, the Directors and department heads have received a monthly statement of operating expenses by departments, with a classification of the expenses within each department. Every Institute member received, in April, a statement of income and expenditures for the first six months of operation and, in October, a similar statement for the full fiscal year, in addition to the Treasurer's summary, which is presented to you today.

General Policies

Among the matters of general policy which were either established or clarified during the year are the following:

Administrative Relationship Between the Textile Research Institute and the Textile Foundation. The administrative inter-relationship between these two organizations, which was established several years ago as a means of furthering collaboration in the pursuit of their common purposes, has proved confusing to many members and non-members in the industry. In order to clarify the administrative picture and make it more truly reflect the factual relationship, the Institute has abolished its office of Director of Fundamental Research and its Fundamental Research Committee, and, at the same time, changed the office of Director of Applied Research to Director of Research, and the Applied Research Committee to Research Committee. The effect of this change is to clearly define, on the one hand, the responsibility of the Textile Foundation and its Research Director with respect to the administration and conduct of the fundamental research which it supports; and, on the other hand, the responsibilities of the Institute and its Research Director with respect to the administration and conduct of the research which it supports. This action involves no change whatever in the close collaboration between the two organizations, but simply clarifies "who is doing what." As heretofore, the Institute's research activities cover fields beyond and around the areas of fundamental research covered by the Foundation and are planned to complement, not to duplicate, the latter. The Institute is building toward the attainment of a stature which will enable

it to add the support of fundamental research to that of its applied research at such time as the Foundation terminates its fundamental research activities.

I have become convinced from discussions of the Board and from conversations with representative members that the best way for the Institute to prepare for the assumption of the Foundation's responsibilities, if and when the Foundation lays them down, is to clarify, now, the administrative duality by disengaging the interlocking of staffs and officers. Cooperation in the operating fields will continue by collaboration between Institute and Foundation staffs, officers and committees. One or two men common to the research committees of the two organizations will be adequate for continuous liaison between them.

Patent Policy. The Institute's basic policy with respect to patents which may result from its activities has been systematized by the joint efforts of the Institute's staff and a committee consisting of Mr. John Bancroft, Jr., Chairman, Dr. Fred Bonnet, Dr. R. E. Rose, and Mr. W. O. Jelleme. Under the general statement of patent policy which was drawn up and approved by the Board, the Director of Research is charged with the responsibility of recognizing and submitting the general outline of ideas which should be patented to the appropriate committee for review and recommendation. It is recommended that the Institute encourage the broad use by its company membership of such patents as it secures, but that it avoid any income to itself from such patents and the necessity of defending them. Contracts with respect to Institute-employee relationships, Institute-Special Project Sponsors, and Institute-Subcontractors, which had previously been developed by the Institute's Research Department were recommended as models.

Library. A Library Committee, comprising Mr. Hopkins, Mr. Jacobs, Major MacMaster, and Dr. Eyring, was asked to submit recommendations for present requirements and future plans for library activities. Its report, which was accepted by the Board, recommended that no expansion of the Institute's library program, such as the acquisition of additional personnel for library work, be undertaken at present. The Committee arranged with the Princeton University Library for the cataloging, without cost, of books belonging to the Foundation and the Institute, with duplicate card indexes to be maintained by each interested department of the Institute and the Foundation, in addition to a set to be retained by the University Library. It was suggested that no attempt be made yet to build up the Institute's library beyond the day-to-day needs of the several departments, except for books which might be acquired by gifts.

The conservatism of these recommendations was based on the thought of not "biting off more than we could chew," with respect both to work and to available funds.

Since the acceptance of the report, further informal discussion has centered around the desirability of expanding our library facilities in conjunction with the abstract service of the JOURNAL, and the answering of specific requests for research information, which is now handled by the Research Department. I recommend that the new administration give this its earnest consideration as one of the primary ways in which the Institute could rapidly increase its usefulness to its members.

It is appropriate in this connection to acknowledge again with gratitude the first important gift of books to the Institute's library in the form of approximately 150 volumes on economic and technical subjects, which were presented in June by Mr. Douglas G. Woolf.

Capital Funds and Building Program

In May of this year, the Directors approved a campaign to raise $100,000 in capital funds, and in September the goal was raised to $250,000 as the minimum amount required to cover the cost of the land and building at Princeton, New Jersey, which we purchased in 1944, and its conversion into a Fundamental Research Laboratory, and to build and equip an Applied Research Laboratory on the same property, as follows:

Cost of 5½ acres and building	$ 24,000
Conversion of building to Fundamental Research Laboratory	91,000
Cost of Applied Research Building and equipment	135,000
Total	$250,000

The total of capital funds received or pledged outright to date is $78,650, plus $10,000 more which is contingent upon securing total funds and pledges in the amount of not less than $250,000. We thus have passed the 35 percent mark on the way to our

minimum goal. As a result of contacts made during recent weeks, our request for contributions to the Institute's capital fund is now being considered by a number of companies which have not yet reported their decision. I hope that a vigorous continuation of this effort by the new administration will result in the completion of our capital funds before the end of this calendar year.

Work on the conversion of our present building started in May and, despite the difficulties of obtaining materials and labor, it is expected that the basement and first floor will be ready for occupancy before January 1. These two floors contain a conditioned room, shop, stock room, three laboratories, library, lounge for study and group meetings, and offices for director and clerical staff. A room on the second floor is being prepared for x-ray work. Piping and electrical connections have been carried to the second and third floors so that these can be completed without disturbing the occupants of the first floor and basement.

By mutual agreement between the Institute and the Foundation, the Foundation's Fundamental Research Group, which is now occupying space in the Frick Chemical Laboratory at Princeton University, will be moved into the new building. The Foundation will provide all apparatus and supplies needed for its work, including x-ray equipment which is already on order.

The present Foundation Group comprises Professor Henry Eyring and Professor Eugene Pacsu of the University faculty, who are part-time employees of the Foundation, and Dr. Robert E. Rundle, formerly of Iowa State College, who is a full-time Foundation staff member. Your five T. R. I. Graduate Fellows are working with this Foundation Group. The Foundation is increasing its own staff as rapidly as it can find suitable personnel, and contemplates a full-time staff of from eight to ten persons, and the assistance of fifteen Graduate Fellows. This is a contribution to industry in one of the important departments of the Institute's long-range program which the Institute would otherwise have to support. In my opinion, our industry can and should make it possible *now*, by the completion of our capital funds, for the Institute not only to provide its Fundamental Research Laboratory for occupancy by the Foundation but also to construct its Applied Research Laboratory to house the Institute's own research, inasmuch as we shall undoubtedly be required to vacate, within a year, the space which we now rent in the Chemical Engineering Laboratory at the University.

Operations

The separate reports of the Publications and the Research Departments and of the Treasurer cover in detail the productive activities which I summarized in my opening paragraphs, and which need not, therefore, be repeated here.

The report of the Research Department contains recommendations on long-range plans which deserve careful study and consideration.

The cooperation, work, and forthright expression of views of the officers, Board members, and staff have been of great assistance in bringing the Institute forward during my term of office, and I am grateful to all who worked actively and loyally on this creative task. The office staff has been very patient with me and cheerfully met my every demand upon their time and services. I regret that my other responsibilities made it impracticable for me to spend more time than I did on the Institute's affairs. It has been an interesting and a challenging experience.

Historical

This is the Fifteenth Birthday of T. R. I. Before vacating the President's chair to resume my chair as a Director for the balance of my term, I would like to remind you that the T. R. I. of today has roots which first sprouted in the middle 'twenties. There were two sets of roots.

One originated in a meeting in Boston in 1926 of twenty American members of the British Textile Institute, of which I was one. The idea that industry itself should promote research on an industry-wide basis germinated in that group and was soon embodied in a non-profit corporation chartered under the laws of the State of New York under the name "Textile Research Council." The Council took a lively interest in the Congressional debate on the bill which created the Textile Foundation. The original officers and executive committee of the Council included: George Gilmore, Chairman; J. T. Broadbent and W. F. Edwards, Vice-chairmen; C. H. Clark, Secretary, Franklin Hobbs, E. D. Walen, Brackett Parsons, D. E. Douty, A. M. Tenney, and E. B. Blake.

The other root originated in the A. A. T. C. C., whose research council and officers were at that same

time fostering the idea of research, in addition to the excellent work of this Association on the development and promulgation of test methods for colorfastness, etc.

In 1930 these two roots of textile research were grafted together by mutual agreement through the formation of the United States Institute for Textile Research. This body took over the charter of the Textile Research Council and began its corporate existence on November 6, 1930, with President Samuel W. Stratton of M. I. T. as its President, thirty-nine annual and seventeen contributing members, and a board which included J. T. Broadbent, Alban Eavenson, Joseph Bancroft, Ernest Hood, L. A. Olney, E. H. Killheffer, P. J. Wood, Robert Blum, and others. The magazine "Textile Research," now our TEXTILE RESEARCH JOURNAL, started as a mimeographed bulletin in February, 1931, and first attained the dignity of print in 1932. In 1940 the Institute adopted its present name—"Textile Research Institute."

During all these years the thinking and activities of the Institute have been guided by certain tenets with respect to non-sectional and industry-wide textile research, which, taken as a whole, made it a pioneer in its field in 1930, and which, today, make it the *only* organization of its kind in the textile research field.

These are:

1. That there is much *basic knowledge* needed by our industry.

2. That a *cooperative effort* to improve the technological foundation on which textile progress must be built is advantageous, not merely from the standpoint of cost, but also because of the greater accomplishment which is obtainable by coordinated action.

3. That this cooperative effort to promote, to do, and to disseminate basic research for the benefit of the textile industry serves, and should, therefore, be supported and guided by, *all geographical section* of the industry.

4. That, despite the inevitable and desirable competition between branches within the industry and between companies within each branch, the basic need is for the industry as a whole to feed a *reservoir of textile knowledge from which streams can flow into each branch and each company in the industry,* to sustain the roots of its own specific developmental and manufacturing operations.

5. That our *industry should finance and control its own basic industry-wide research* apart from Government-controlled research financed by taxation.

In short, *T. R. I. is the only existing industry-controlled instrument with a non-sectional, industry-wide approach to the problem of raising the technological level of the textile industry.*

In addition to its general research efforts, it has also done, and is organized to do, special projects for any group of two or more company members which provide the funds, guide the work, and enjoy the benefits, for a period, mutually agreed upon by T. R. I. and the sponsoring group, before the results are released to other members and the industry as a whole by publication.

The natural question to ask is why T. R. I. has made such slow material progress.

With no intention of minimizing past weaknesses and the pitfalls which have beset its path, I think we should recognize several fundamental factors which make it unlikely that T. R. I. could have enjoyed a meteoric rise even under the guidance of a board of geniuses instead of a Board of Directors!

One was the coincidental formation of the Textile Foundation by Act of Congress in the same year in which the Institute was born. It was difficult to convince an industry which was basically *not* research-minded that it should pay out good money to support cooperative research in view of the existence of a Foundation, with what were popularly believed to be huge funds, which had been expressly created to support research for the good of that industry. The more rapid growth of Institute membership and of income from industry in recent years has been assisted by the elucidation of the fact that the Foundation is spending its principal and has a life expectancy of relatively few years.

But the main obstacle to the Institute's rapid growth lies in its very reason for existence—namely, its aim to unify the diversity of branches and interests within the textile industry on a common program of research. It would not have been nearly as difficult to create an Institute for the rayon industry or for the wool industry, or, as has been demonstrated, for the cotton industry. The British developed their Industry Research Associations on these sharp lines of demarcation between the classical branches of the industry, with the additional prop of partial support by the Government.

T. R. I. is founded on a broader and more independent concept—namely, on the idea that there is

much basic knowledge needed about the structure and properties of fibers, about the principles of converting a mass of fibers into a yarn, and groups of yarns into a fabric, about the wetting of textiles, the drying of textiles, the blending of fibers, the action of resins and other agents on fibers and fabrics, and many other problems which are common to all branches of the industry. T. R. I. believes that a central staff of scientists and engineers working on fundamental and applied research problems which are basic to a wide cross-section of our industry (with auxiliary facilities of library, publications, and the training of graduate textile scientists) will cost each branch less, and benefit each branch more over the long pull. And it embodies a mechanism by which an industry branch can do some work in its own pet corner if it so desires, while still remaining in close association with the central basic program.

The value received from an investment in T. R. I. is not very tangible or visible, and this is the third basic factor which has made tough going for the Institute. But the value received, though intangible, is very real. No matter what fiber you have been wedded to, T. R. I. will be digging out basic information about others which you may want to use; no matter what technique you have grown up with, T. R. I. will be unearthing basic principles on which your production processes work; no matter what stage of the textile process you are at, from the making of fibers to the making of finished fabrics, the fibers you sell (or buy) and the fabrics you buy (or sell) will be better if you help to raise the level of technical knowledge of the industry.

In a textile world in which the old, clearly-defined boundaries between different fibers, different spinning processes, and different methods of converting fibers and yarns into fabrics and garments are disappearing, the value of this instrument, T. R. I., can be as great as the industry wills to make it.

November 9, 1945

T. R. I. Annual Meeting

THIS year's annual meeting of Textile Research Institute, Inc., held November 9 at the Waldorf-Astoria Hotel in New York, brought a record attendance of over 350.

At the members' meeting in the morning a new set of By-Laws was adopted. The purpose of the new By-Laws is to clarify the functioning of the Institute as a closely-knit scientific organization with a professional staff and management, charged with directing the work in all its phases and reliant on the board of directors and members for policy guidance and financial support only. New directors elected were: H. Wickliffe Rose, American Viscose Corp.; Malcolm Campbell, North Carolina State College Textile School; H. W. Whitcomb, Marshall Field, Manufacturing Division; Curt Forstmann, Forstmann Woolen Co.; Richard T. Kropf, Belding-Heminway-Corticelli Co.; Harold Walter, Uxbridge Worsted Co.; Dr. Miles Dahlen, E. I. du Pont de Nemours & Co., Inc.; Daniel Curll, Jr., Rumford Chemical Works.

In accordance with the new By-Laws the newly elected board of directors met and elected the following officers: H. Wickliffe Rose, chairman of the Board of Directors; J. E. Bassill and Curt Forstmann, vice-presidents; D. B. MacMaster, secretary; Robert R. West, treasurer.

The new By-Laws provide that the president of the Institute (soon to be appointed by the Board) will be the executive officer of the Institute. A complete listing of officers, directors, and personnel of advisory committees will be found on the inside page of the back cover in the December issue of TEXTILE RESEARCH JOURNAL.

Forenoon and afternoon technical sessions were held at which reports were given of the research in progress by The Textile Foundation and by the Institute at Princeton, N. J.

Following the luncheon, the guest speaker, Prof. H. D. Smyth, head of the Palmer Physical Laboratory of Princeton University, spoke on the subject "Atomic Energy." Dr. Smyth is the author of the recent official report on the development of the atomic bomb.